pulse crops IN ALBERTA

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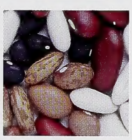
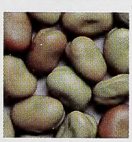
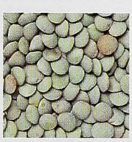


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General Pulse Production

Field Pea

Dry Bean

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general pulse production

Pulses: World Production and Distribution

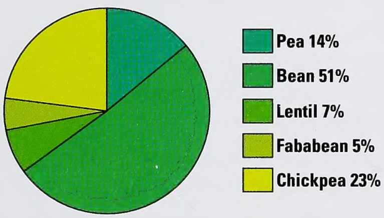
Importance of Pulses in the World

Pulses are edible seeds of annual legumes and are produced throughout the world on plants such as field pea, dry bean, lentil, chickpea, lathyrus, soybean, fenugreek and fababean.

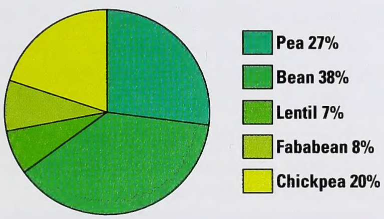
World production of major pulses (1998)

In 1998, approximately 45 million tonnes of pulses were produced on approximately 49 million hectares throughout the world
(source: Food and Agriculture Organization of the United Nations - FAO, 1998).

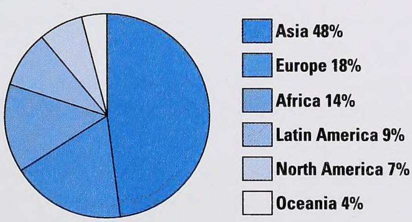
Total Area By Crop



Total Production By Crop



Production By Continent



Records of pulse use date back more than ten thousand years, spanning the globe. Evidence of pulses has been found in Egyptian pyramids, in Switzerland from the Stone Age, in the ruins of Troy, and century-old pea seeds have even been discovered buried in Hungarian caves.

Archeological evidence suggests that pea was grown in the Eastern Mediterranean and Mesopotamia at least five thousand years ago, and in Britain as early as the 11th century. Lentil was a favorite dish of the ancient Greeks, and eight thousand years ago, Indians in Peru cultivated a lima bean similar to ones we produce today.

Today, pulses are an important source of protein, particularly for developing countries. Pulses have two to three times the protein content of cereal grains and provide about 10 per cent of the world's dietary protein.

Throughout the world, the majority of pulses or grain legumes are eaten by humans, although a substantial amount of North American, European and Australian field pea production is traded and utilized in the livestock industry.

World pulse production, import and export activities are illustrated in the following Tables 1 through 5:

Table 1. World field pea production imports and exports (000 MT)

Location	Production	Imports	Exports
Europe	7,304	1,640	1,229
Asia	2,126	288	3
Canada	1,762	10	870
US	305	39	100
Oceania/Australia	395	3	274
Africa	354	52	4
Latin America	80	25	8

Source: FAO, 1997

Table 2. World dry bean production imports and exports (000 MT)

Location	Production	Imports	Exports
Europe	560	422	80
Asia	8,308	160	1,265
US	1,490	59	369
Canada	161	19	131
Oceania/Australia	38	9	30
Africa	2,067	36	59
Latin America	4,786	249	311

Source: FAO, 1997

Table 3. World chickpea production imports and exports (000 MT)

Location	Production	Imports	Exports
Europe	82	104	5
Asia	8,010	225	264
Oceania/Australia	240	156	380
Africa	296	71	6
Latin America	199	-	98

Source: FAO, 1997

Table 4. World fababean production imports and exports (000 MT)

Location	Production	Imports	Exports
Europe	286	243	132
Asia	1,843	29	99
Canada	12	-	2
US	-	2	2
Oceania/Australia	137	-	107
Africa	1,012	32	5
Latin America	146	2	1

Source: FAO, 1997

Table 5. World lentil production imports and exports (000 MT)

Location	Production	Imports	Exports
Europe	45	163	8
Asia	2,225	249	181
Canada	379	3	301
US	85	15	53
Oceania/Australia	120	1	-
Africa	84	119	2
Latin America	32	145	-

Source: FAO, 1997

History and Importance of Pulses in Canada

Pulses play a colorful part in the dietary history of North America. Hearty "pea soup," introduced in Canada by early French settlers, was popular with pioneers who settled the West. Baked beans were a staple for ranchers riding in winter – they carried frozen beans and carved off daily portions, heating them over an open fire. Even today, baked beans are popular at rodeos and barbecues.

- between 1883 and 1902, eastern Canadian farmers produced an average of 720,000 acres of field pea each year
- by 1970, only 62,000 acres were grown in all Canada, with about 70 per cent of the production in Manitoba
- during the 1970's wheat glut, Western farmers turned to pulses to diversify, growing lentil, pea and other special crops
- pulse crops traditionally didn't compete with weeds well, but the introduction of herbicides such as Treflan® made them more viable
- newer short-season, high-yielding varieties enhanced the commercial acceptance of lentil and pea crops
- since the 1970's, pulse production in Western Canada has increased dramatically, with the largest increases in pea and lentil crops, and in 1998, chickpea gained significantly in Saskatchewan and southern Alberta
- a market for feed pea was established in Europe in 1985, and continued good returns and consistent markets have increased acreage to a record 2.7 million acres in 1998
- several other factors have encouraged increased acreage of pulse crops on the Canadian prairies:
  - reduced summer fallow acreage
  - longer crop rotations
  - continuous cropping
  - direct seeding
  - the nitrogen-fixing ability of pulses
  - improved control of disease and weeds through better rotations
- acreage of pulse crops in Western Canada is at a record high, with gross sales in 1996 of over $462 million
- pulse production increases will likely continue, even with improved cereal grain prices, as farmers improve their knowledge of pulse production and continue to include pulses in sustainable crop rotations

Adaptation Characteristics of Pulse Crops

	Lentil	Pea	Chickpea	Dry Bean	Fababean
Optimal Temperature	cool	cool	warm	warm	cool
Spring Frost Tolerance	tolerant	tolerant	tolerant	not tolerant	tolerant
Drought Tolerance	tolerant	less tolerant	very tolerant	less tolerant	not tolerant
Maturity	range of early to late varieties	range of early to late varieties	very late	late	late
Potential on Brown Soil	excellent on fallow	excellent under irrigation, fair to poor on dryland stubble	excellent on fallow	excellent on irrigation, fair on dryland summer fallow	excellent on irrigation, poor on dryland
Potential on Dark Brown Soil	excellent on stubble	excellent on irrigation, fair to good on moist stubble	excellent on fallow	excellent on irrigation, fair on fallow and moist stubble	excellent on irrigation
***Potential on Moist Dark Brown Soil**	excellent on stubble	good to excellent on stubble	fair on stubble	fair to good on fallow and moist stubble	fair to good
Potential on Black Soil	fair to good (high management)	excellent	very poor	fair (high management)	good to excellent
***Potential on Moist Black Soil**	poor	excellent	very poor	very poor	excellent
Potential on Grey Soil	poor	excellent	very poor	very poor	good to excellent
Potential on Peat Soil	very poor	good	very poor	very poor	poor (for silage only)
Average provincial Seed Yield (lbs./ac.)	1200	2400	800	1000 dryland 2000 irrigation	2400 dryland 3000 irrigation

From various sources including SAF 1994, Dr. A.E. Slinkard, Personal Communication, Dr. C. McKenzie, AAFRD, 1997 Update, Saskatchewan Pulse Production Manual.
* Adequate fall period sub-soil moisture reserves.

Other adaptability factors

	Lentil	Pea	Chickpea	Dry Bean	Fababean
Field Selection	well drained, level to slightly rolling	well drained, level to slightly rolling	well drained, level to slightly rolling	well drained, level	well drained, level to slightly rolling
pH	6.0 - 8.2	4.8 - 8.2	<8.2***	<8.2***	6.5 - 8.2
Soil Salinity	no information available	sensitive	no information available	sensitive, conductivity <3.0 mmhos./cm.	moderately sensitive, conductivity < 3.5 mmhos./cm.
Water Use Efficiency kg/ha/mm (seed)	6.4	10.4	8.4 (desi type)	8.0	10.0 22.0 (silage)

***Lower limits - no data available for lower limits

Benefits of Pulses in Crop Rotations

There are many advantages to having pulse crops in rotation, and the benefits extend beyond the year they are grown.

Pulses extend and diversify crop rotations, increase nitrogen availability, improve soil tilth and contribute to soil organic matter. They also reduce dependence on summer fallow, break cereal disease cycles, offer unique opportunities for grassy weed control and broaden market opportunities.

Overview: How Pulses Improve Crop Rotations

For centuries, producers growing cereal crops in a rotation with pulses generally found an increase in the yield of cereal crops. The availability of inexpensive commercial fertilizers resulted in a move away from crop rotations to cereal monocropping on the prairies. More recently, increased fertilizer costs and low cereal prices have created a renewed interest in pulse crops.

Agronomic Benefits

Researchers agree there is a yield benefit to cereal crop rotations that incorporate pulse crops (although they disagree on the size of this benefit and its source).

- the precise yield benefit of cereal crops following pulse crops is difficult to quantify
- the benefit is affected by growing conditions, soil fertility and field management history
- it appears the benefit is greater in soils with poor nitrogen (N) status (i.e. less fertile soils) and in higher moisture regions – studies done on the Canadian prairies consistently show little or no benefit when moisture is limited
- long-term studies indicate the effects of pulses on soil fertility and soil tilth are cumulative
- it's reasonable to expect that soil N status, soil tilth and soil water-holding capacity will improve in a long term cereal-pulse rotation
- it's also reasonable to expect N fertilizer requirements will decrease during a long-term pulse-cereal rotation
- pea appeared to give the most consistent results in the studies reviewed

The positive effect of pulse crops on cereal yields appears to be due to a number of factors:

- pulses improve soil N status by fixing atmospheric N for use by other crops and by having a higher N content in their residues
- pulses also act to conserve N present in the soil by fixing atmospheric N
- pulse crops serve as a "break crop" and help reduce soil-borne diseases; growing a variety of crops also gives a producer more options in weed and pest control

Economic Benefits

Agronomic benefits of pulse crops translate into economic benefits, mostly due to reduced costs for the crop that follows the pulse crop.

Economic effects of including pulses in a rotation:

- reduced fertilizer cost to grow pulse crop
- the added nitrogen benefits of pulse crops allow for reduced nitrogen fertilizer application for cereal and oilseed crops in rotation in the first two years after pulse crops
- pulses increase the yield and quality of the following cereal crop, and may increase crop grade and revenue
- possible lower fuel costs (improved soil tilth may result in less tillage)
- a more diverse crop base may help reduce risk – pulses are high-value crops and can improve farm profitability and reduce reliance on cereal production
- pulse crops are cash crops, so they can be marketed without quota restrictions throughout the year to contribute to the cash flow of a farm operation
- while the profitability of a cereal-pulse rotation may vary from year to year, a cereal-pulse rotation appears to be more profitable over longer periods

The following costs associated with adding pulses to a rotation may partially offset some of the benefits:

- the high cost of seed and herbicides for pulse crops may offset the reduction in cost for N fertilizer
- higher protein content in a barley crop after a pulse crop reduces the chance of producing malt barley
- possible higher machine costs due to slower seeding, swathing and combining speeds for pulse crops

The economic effects of adding pulse crops to a rotation can be mixed – for example, cereal-pulse rotations can be less profitable than cereal-fallow rotations when there is low rainfall. However, most studies concluded that adding pulse crops to the rotation would help to increase the long term profitability of a farm, especially in areas of good rainfall.

A Detailed Look at Agronomic Benefits of Pulses in Rotation

The following information gives specific examples of agronomic observations that support the benefits of including pulse crops in rotations.

Cereal yields following pulse crops are often higher than when following cereals.

- at Swift Current, wheat following lentil yielded the same as wheat following wheat
- at Melfort, Scott and Saskatoon, cereals (barley or wheat) following lentil or pea yielded substantially more on average than those following cereals
- at Swift Current (Brown soil zone), cereal yields on lentil stubble were approximately 65 per cent of cereal yields on fallow; in the moister sites (Dark Brown and Black soil zones), cereal yields on lentil or pea stubble were approximately 90 per cent of yields on fallow
- advantage gained from pulse crops over cereals as the preceding crop in the rotation may depend on moisture availability – when moisture limits production, pulses provide less yield benefit, and may even reduce yield, possibly because they leave very little stubble for snow trapping

In a separate study at Swift Current, with a long term lentil-wheat rotation, nitrate nitrogen in the rooting zone was higher in a wheat-lentil rotation than in any other continuous cropping rotation.

- this increase in soil nitrogen resulted in a reduction in the fertilizer nitrogen requirements and a consistent 1 per cent boost in the grain protein of wheat
- the protein boost was attributed to an improved relationship between the breakdown of pulse crop residues and wheat crop development

At Melfort, pulses had a beneficial effect that continued into the third year of the rotation.

- barley yielded more following a pulse than following barley, even when fertilizer nitrogen was applied to the required level
- in the third year, wheat yields were still substantially higher in the pulse rotation than in the cereal rotation
- different pulses produced their maximum effect at different times – the effect of fababean was strongest in the second year while pea had the strongest effect in the third year

In another crop sequence study at Melfort, the yield of a number of crops was higher following a pulse than following a cereal (Table 6 and 7).

- however, pea did not yield higher when following a pea crop – pea yields were higher following a cereal in rotation, and higher following an oilseed in rotation than when following pea or pea canola mix

Table 6. Pulse rotation effect in several different crops at Melfort

Crop	**Yield After Pea as a % of Yield After Wheat**
Flax	126
Barley	140
Canola	126
Preceding Crop	**Pea Yield as % of Yield After Pea**
Flax	115
Barley	130
Wheat	119
Canola	113
Peaola (Pea-Canola Intercrop)	103

Source: Townley-Smith 1995

Research on cropping sequences at Melfort and Aylsham (NE Saskatchewan) (Moist Black soil zone) demonstrated that yield of cereals was greater on stubble of oilseeds or pea than on cereal stubble (Table 2).

- similarly yield of oilseeds was higher on cereal or pea stubble, and pea yield was greatest on cereal stubble
- the studies were conducted under conditions where disease potential was minimal, suggesting that these responses were independent of diseases
- it is believed that these results can be extended to drier environments

Table 7. Relative yield (%) of crops grown on their own stubble and stubble of other crops at Melfort and Aylsham, Sask. (Moist Black soil zone) during 1990 to 1992

	Crop				
	Pea	**Flax**	**Canola**	**Wheat**	**Barley**
Stubble	**% of check = 100**				
Own	100	100	100	100	100
Cereal	125	111	152	98	109
Oilseed	114	109	177	131	138
Pea	100	142	196	147	152

Source: Adapted from Townley-Smith, report to Sask. Pulse Crop Development Board, 1994

A recent study at Indian Head has shown that nitrogen fixation is greater in zero-tillage systems than with conventional tillage.

- nitrogen fixation was 10 per cent higher in lentil crops and 31 per cent higher in pea crops when the zero-tillage system was used

- it was also shown that nitrogen fixation was improved for lentil grown in diversified rotations in both zero-till and conventional tillage – the cause of this improved nitrogen fixation has not been determined but the less stressful crop establishment environment with zero-tillage may be beneficial to nitrogen fixation

Nitrogen fixation by the pulse crop is an important part of the total benefit of growing a pulse in rotation.

- pulse crops fix nitrogen (in association with *rhizobia*) and release it in an available form when their residues decompose
- the amount of nitrogen fixed can be substantial and is largely a function of the dry matter yield (about 40 lb. of nitrogen per tonne of dry matter)
- the "pulse effect" can be the equivalent to the boost the crop would receive if given 50 lb./ac. or more of fertilizer nitrogen
- most of the fixed nitrogen is removed as protein in the harvested seed
- the pulse residues usually contain only 1 per cent nitrogen (slightly more than cereal residues), but pulse crop residues break down very rapidly, releasing this nitrogen and making it available to the succeeding one or two crops
- in spite of this, 50 per cent of the nitrogen in the pulse crop residue is available to the following grain crop

The boost in productivity that is not due to nitrogen is termed the "non-nitrogen benefit." Many factors can contribute to this benefit, and work in combination with each other, so the effect of individual factors is difficult to determine.

- pulse crops improve soil tilth – soil organic matter may actually be reduced following pulses (relative to cereals) because less dry matter residue remains, but relative to fallow, organic matter can be greater following pulses
- crop rotations that include pulses can substantially increase soil microbial activity and may increase nutrient availability (including phosphorus) (Refer to Figures 1 and 2)

A real benefit may be realized in cereal crops that follow a pulse because the pulse year interrupts pest cycles.

- most cereal diseases do not affect pulse crops
- soil-borne root rots in continuous wheat (or wheat-fallow) or continuous barley rotations can cause average yield losses of 5 to 10 per cent – these yield losses may be reduced by inserting a pulse crop into the rotation
- insects such as grasshopper may find pea much less palatable than wheat
- weeds may have different abilities to survive in pulse and cereal crops – for example, a wide range of grassy weeds can be controlled over a wide window of growth stages

Figure 1. Barley yield response to N rate on oilseed (canola), cereal (wheat) and pulse (pea) stubble at Melfort, 1994 (Beckie and Brandt, 1997).

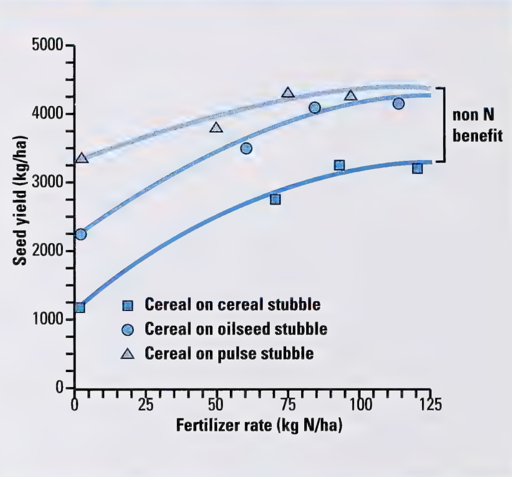


Figure 2. Canola yield response to N rate on oilseed (canola), cereal (wheat) and pulse (pea) stubble at Melfort, 1994. (Beckie and Brandt, 1997)

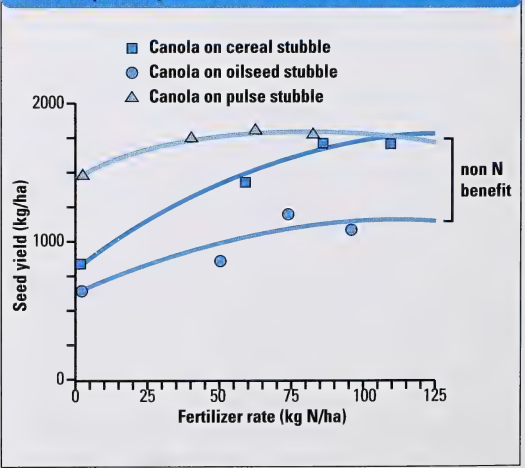


Table 8 and 9 following represent the final two-year data summary of Pulses in Rotation Study conducted by Ken Lopetinsky, Pulse and Special Crops Specialist, and Zone 3 Alberta Pulse Growers Commission (APGC).

Table 8. Summary of 1995 crop yields at three sites of pulse crops in rotation study

Crop Sequence		Overall Average Yields (3 sites, 9 reps) at corrected moisture content	
1994	1995	lbs./ac.	bu./ac.
Wheat[1]	Barley[1]	3035 bc	63.2
Wheat	Field Pea	2752 bc	45.9
Wheat	Lentil	1157 d	19.3
Wheat	Fababean	1471 d	24.5
Fababean	Barley	2567 c	53.5
Lentil	Barley	3229 b	67.3
Field Pea	Barley	3940 a	82.1

a,b ... Yields in the column followed by the same letter are not statistically different.
[1] Continuous cereal rotation received 60 lb. N/ac./yr., other rotations received no added nitrogen.

Table 9. 1996 CAESA* rotational study yields of barley on various 1995 crop stubbles 1996 barley rotation

1996 Barley Rotation 1996 on 1995 on 1994	Barrhead SITE 1	Riviere Qui Barre SITE 2	Westlock SITE 3	Overall Average
	Average of 3 Reps Barley Yield (lb./ac. at 14.8% m.c.)			
Barley on Barley on Wheat (continuous cereal) + 60 lb. N/ac./yr.	3258 b	2371 c	2584 b	2738 b
Barley on Barley on Fababean	2316 c	2218 c	2186 c	2240 c
Barley on Fababean on Wheat	3709 a	2157 c	2889 a	2919 b
Barley on Barley on Lentil	2259 c	1611 d	1951 d	1940 c
Barley on Lentil on Wheat	3266 b	2765 b	2325 c	2786 b
Barley on Barley on Pea	2469 c	2251 c	1846 d	2189 c
Barley on Pea on Wheat	3550 a	3259 a	3010 a	3273 a

*CAESA = Canada Alberta Environmentally Sustainable Agriculture Agreement
a,b ... Yields in the column followed by the same letter are not statistically different
m.c. = moisture content

The data in Table 8 and 9 show benefits received from barley grown without added nitrogen on pea stubble compared to barley grown on wheat stubble in 1995 with 60 lb. N/ac. added (Table 3) and barley grown with 60 lb. N/ac. added on barley stubble in 1996. In both years and over all three sites, the barley on pea stubble out-yielded barley on cereal stubble with 60 lb. N/ac. added.

- the previous pea crop yield was in excess of 3000 lb./ac. (50 bu./ac.) – if pea yields are much lower due to drought or management, the resulting barley yield without added nitrogen would have been much lower
- for producers fertilizing barley crops to an optimum level, some nitrogen fertilizer addition is warranted on pea stubble to achieve these high barley yields the next year
- some producers apply one third of the normal barley nitrogen rate – higher nitrogen rates delay the maturity of the cereal grown on pea stubble and increase the chance of severe lodging
- the overall Pulses in Rotation Study confirms benefits of pulses (especially field pea) to succeeding cereal crops when the pea yields are optimized

Literature Review

A detailed review of current literature supports the agronomic and economic benefits of including pulses in crop rotations.

Part A: Yield Effect of Pulses on Cereals

It has been known for centuries that growing cereal crops in a rotation with pulses generally increases the yield of the cereal crops. This literature review examines scientific studies and field trials to answer three questions:

1) How large is the benefit from pulse crops to cereal crops in a rotation?
2) Where does the benefit come from?
3) Are pulse-cereal rotations more profitable than continuous cereal rotations?

The following is a brief summary of pulse rotation studies, with special emphasis on studies done on the Canadian prairies. The review concentrates on more recent studies (i.e. studies done in the 1980's and 1990's).

Studies Examining the Yield Effect of Pulses on Cereals and the Source of the Effect:

Stevenson and van Kessel.1996. The Nitrogen and Non-Nitrogen Benefits of Pea to Succeeding Crops. *Canadian Journal of Plant Science*. 76: 735-745

- a study of pulse-wheat (PW) and continuous wheat (WW) at three locations in Saskatchewan
- wheat grain yield was increased by 43 per cent in the PW rotation over the WW rotation

- researchers concluded that only 8 per cent of the yield increase was due to the N contained in the pulse residues

Wright, A.T. 1990. Yield Effect of Pulses on Subsequent Cereal Crops in the Northern Prairies. *Canadian Journal of Plant Science*. 70: 1023-1032

- two rotations (pulse-barley-wheat and barley-barley-wheat) were compared over two cycles (six years)
- the yield of the cereal increased (on average) by 21 per cent the first year after a pulse crop and by 12 per cent the second year after a pulse crop

Wright, A.T. 1990. Quality Effects of Pulses on Subsequent Cereal Crops in the Northern Prairies. *Canadian Journal of Plant Science*. 70: 1013-1021

- pulse-barley-wheat rotation compared to a barley-barley-wheat rotation
- fababean, pea and lentil had similar effects on quality of following barley crop
- concluded that increase in barley quality was due to residual N from pulses and from the "rotation effect"

Townley-Smith. Crop Sequences Involving Pea in NE Saskatchewan. 1994

- various crops were grown in different sequences
- all crops had the highest yield on pea stubble (except for pea grown on pea stubble)
- cereals grown on their own stubble had lower yields and seed size than when grown on pea stubble

Bourgeois and Entz. 1996. Influence of Previous Crop Type on Yield of Spring Wheat: Analysis of Commercial Field Data. *Canadian Journal of Plant Science*. Vol. 76: 457-459

- compared pea-wheat, oilseed-wheat, flax-wheat and wheat-wheat
- on average, over all 11 years, yield of wheat after pea was 11 per cent greater than yield of wheat after wheat
- the yield increase after a pulse crop was often not seen in a dry year

Bremer and van Kessel. 1992. Plant Available Nitrogen from Lentil and Wheat Residues During a Subsequent Growing Season. *Soil Science Society of America Journal*. 56: 1155-1160

- a study to measure lentil residue N and quality of source
- found that N from lentil straw did not leach or become lost through denitrification
- 26 per cent of N from lentil green manure and fertilizer was lost to leaching and denitrification in 6 weeks after planting

Campbell, Zentner, et al. 1992. Comparative effects of Grain Lentil-Wheat and Monoculture Wheat on Crop Production, N-economy and N Fertility in a Brown Chernozem. *Canadian Journal of Plant Science*. 72: 1091-1107

- a 12-year study comparing a wheat-lentil (WL) rotation to continuous wheat (WW), wheat-fallow (WF) and fallow-wheat-wheat (FWW) done in Saskatchewan
- WL rotation did not increase wheat grain or straw yield
- appears there is an increase in the mineralization of N during the growing season in WL and therefore a lower N fertilizer requirement
- long term WL rotations appear to increase the N supplying power of the soil over time

Lopetinsky, K and Winchell, R. 1997. *Pulse Crops in Cropping Rotations*. Alberta Agriculture, Food and Rural Development. (unpublished)

- compared continuous cereal (WWBB) to pea rotations (PWPB; WPBB), lentil rotations (LWLB; WLBB) and fababean rotations (FWFB; WFBB) at three sites in North Central Alberta
- barley on pea stubble yielded higher than continuous cereal in both 1995 and 1996 at all three sites
- barley on lentil stubble yielded higher than barley on cereal stubble at two sites in 1995 and one site in 1996
- barley on fababean stubble yielded higher than barley on cereal stubble at two sites in 1996

Brandt, S.A. 1997. *Sustainable Crop Rotations*. Agriculture and Agri-Food Canada. (unpublished)

- general review of studies on benefits of crop rotations
- identifies following benefits:
  - increased yield: 41 to 52 per cent increase of barley following pea and increases of 20 to 47 per cent of wheat following pea, as compared to continuous wheat or barley
  - pulses increase the amount of N that soil can supply (increases N over time)
  - enhanced weed control (especially of grassy weeds)
  - reduces plant diseases

Seratne, R., and Hardarson, G. 1988. Estimation of Residual N Effect of Fababean and Pea on Two Succeeding Cereals Using 15N Methodology. *Plant and Soil*. 110: 81-89.

- fababean and pea were grown in rotation with barley and sorghum
- N content of cereals increased following pulses

- authors concluded that pulses did not improve soil N status in this study but had a "N conserving effect" (i.e. because of ability to fix N, they didn't deplete soil N as much as a cereal would)
- also concluded that the "rotation effect" was responsible for some of the increased yields

Jensen, E.S., and Haahr, V. 1990. The Effect of Pea Cultivation on Succeeding Winter Cereals and Winter Oilseed Rape Nitrogen Nutrition. *Applied Agricultural Research*. 5(2); 102-107.

- effect of residual N from pea was compared to oats in rotation with either winter wheat, winter barley or winter oilseed rape
- grain yields of winter cereals not fertilized with N but grown after pea were equivalent to cereal yields after oats with a spring application of 20-30 kg N/Ha

McEwen, J., Darby, R.J., Hewitt, M.V., and Yeoman, D.P. 1989. Effect of Field Bean, Fallow, Lupin, Oats, Oilseed, Rape, Pea, Ryegrass, Sunflower and Wheat on Nitrogen Residues in the Soil and the Growth of a Subsequent Wheat Crop. *Journal of Agricultural Science*. 115: 209-219

- examined wheat and various "break crops" including spring pea
- found a reduction of diseases in wheat to negligible amounts following a break crop; wheat disease levels were significant in continuous cereal rotation
- N fertilizer requirement of wheat was reduced when wheat followed pea
- wheat after pea had a higher yield than wheat after wheat or wheat after oats

Evans, J., et al. Wheat Response after Temperate Crop Legumes in South- Eastern Australia. *Australian Journal of Agricultural Research*. 42: 31-43

- yield of wheat after pea increased, result was variable with site and year
- increased uptake of N by wheat after pea by 36 kg of N/Ha on average

Rowland, I.C., Mason, M.G., Pritchard, I.A., and French, R.J. 1994. Effect of Field Pea and Wheat on the Yield and Protein Content of Subsequent Wheat Crops Grown at Several Rates of Applied Nitrogen. *Australian Journal of Experimental Agriculture*. 34: 641-646.

- compared response to several fertilizer rates of wheat after wheat (WW) and wheat after pea (PW)
- total DM (dry matter) yield of PW was greater than WW in 11 of 17 trials
- PW also had a higher grain content than WW
- authors determined that the yield increase was due to N supply from pea residue and "conserved N" in 9 trials

Smiley, R.W., Collins, H.P., and Rasmussen, P.E. 1996. Diseases of Wheat in Long Term Agronomic Experiments at Pendleton, Oregon. *Plant Disease*. 80: 813-820

- found diseases to be less damaging in a wheat-pea rotation than in annual wheat or wheat fallow rotations

Part B: Economic Benefits and Costs

Agronomic benefits of growing pulse crops translate into economic benefits. With the exception of Lopetinsky and Winchell, none of the studies reviewed examined the economic effects of adding pulse crops to a cereal rotation.

The majority of literature on the economics of crop rotations on the Canadian prairies deals with fallow-cereal rotations. Some studies do examine the use of pulses, but only when they are used as a fallow substitute and a green manure, and studies do not apply to higher moisture areas. There are a few studies that examine the economic value of pulse-cereal rotations. These studies are described below:

Nagy, Cecil. 1997. *The Economics of Changing to a Reduced Tillage System in the Parkland Region of Saskatchewan*. University of Saskatchewan (unpublished)

- compared a canola-wheat-barley-flax-wheat-fallow rotation (1) to a canola-wheat-pea-wheat rotation (2) and a canola-winter wheat-pea-wheat rotation (3)
- found that rotation (2) was the most profitable and least risky for all three tillage systems examined (conventional, minimum till and no till)

Lopetinsky, K and Winchell, R. 1997. *Pulse Crops in Cropping Rotations*. Alberta Agriculture, Food and Rural Development. (unpublished)

- found cereal-pea and cereal-lentil rotations more profitable than continuous cereal at two sites
- found savings due to lower N fertilizer requirements in pulse-cereal rotations were offset by increased seed and herbicide costs
- net income from barley after pulses was considerably higher than barley planted after barley

***Economic Analysis of CASI Crop Rotation Study*. (unpublished)**

- compared continuous cereal to pea-cereal, lentil-cereal and fababean-cereal rotations

- pea-cereal rotations were found to have the highest net return over the three-year period
- fababean-cereal rotation gave negative net revenue
- rotations using pulses as a plow-down crop were the least profitable (had highest losses)

Alberta Agriculture. Consensus of Costs and Returns. Nos. 211, 271, 273, 284
Alberta Agriculture. Costs and Returns for Selected Crops, Central Region. 1995 & 1994

- a review of these publications shows that pulse crops add to the profitability of a rotation by reducing fertilizer costs and because of the generally high value of pulse crops
- these advantages can be offset by higher seed and herbicide costs associated with growing pulses

Pulse Crop Rotation Study

A pulse crop rotation study was conducted by Alberta Pulse Growers Commission (APGC)-Zone 3 and the Canada Alberta Environmentally Sustainable Agriculture Agreement. It provided a very good opportunity to gather data on yields of cereals and pulses in rotations at three sites over a four-year period.

The Zone 3 study supports a positive effect on net income and positive agronomic benefits from including pulses in a rotation. A detailed analysis of costs and returns of six different cereal/pulse rotations and one continuous cereal rotation was done and is reported in the final report. The analysis determined pea/cereal rotations and lentil/cereal rotations produced higher net income than continuous cereal rotation, while fababean/cereal rotation produced net income lower than continuous cereal.

From this study, the 'Pulse Crop Rotation Planner' was developed, so crop producers and crop specialists could use the information gained from the APGC-Zone 3 study to plan and evaluate rotations for their own specific conditions. The results of the study may not apply to cropping experience in other locations, so it will be necessary to adjust and adapt the study's information.

Provided in the 'Pulse Crop Rotation Planner' is basic guideline information for crop yields, crop prices, nitrogen expenditure and other crop production expenses. Some notes on the Planner include:

- yield guidelines are based on average yields experienced over four years at three sites
- nitrogen costs are representative of those experienced in the study (i.e. barley yield in the continuous cereal rotation is 70 bu./ac. and nitrogen expense is $18.00/ac.; barley yield following pea in the pea/cereal rotation is 75 bu./ac. and nitrogen expense is $3.00)
- other crop production costs (herbicides, fuel, oil/lube, machinery repairs, etc.) are from the 1997 'Crop Projections' publication updated annually by Production Economics and Statistics Branch of Alberta Agriculture
- prices used in the Planner are a five-year average for each crop

The 'Pulse Crop Rotation Planner' allows producers to evaluate an entire rotation rather than just individual crops by calculating an average net return for all crops in the rotation. Worksheet #2 allows producers to look at various combinations of crops to produce optimum net return by using crops that the producer prefers to grow.

Pulse Crop Rotation Planner

This planner is provided to help you decide what crop rotation is best for your farm.

The crop production budgets in this planner are based on 1998 Crop Projections.
Current prices may vary from those used in the budget – check local prices and adjust the budget to reflect expected market conditions. Your costs may be different, so review costs to see if all apply to your farm. **Seed prices for pulse crops vary considerably depending on variety and location – check seed prices with seed growers and retailers in your area and adjust the budget accordingly.**

Other considerations:

- budgets are based on a conventional tillage system – if you use a minimum tillage or zero-till system, you will need to adjust the budget to reflect your tillage costs
- budgets provide projected yields based on trials conducted by the Alberta Pulse Growers Commission-Zone 3 (yields and costs can vary considerably between producers and areas)
- budgets are given as guidelines to develop estimates for your farm – your past farm records (adjusted for expected changes) can be used to develop your estimates and entered in the worksheet provided with this planner
- short-run cropping decisions can be made on the basis of returns over cash costs – for long-term decisions, consider return on your investment

Pulse crop production costs and returns per acre

Update 1998	Crops seeded on cereal stubble				
Revenue	**Barley**	**Wheat**	**Pea**	**Lentil**	**Fababean**
(A) Average yield (bu./ac.)*	70	42	45	23	35
(B) Projected price ($/bu.)**	2.40	4.00	4.25	10.20	5.88
(C) Revenue (AxB)	**168.00**	**168.00**	**191.20**	**234.60**	**205.80**
Cash Expenses					
Seed	12.00	13.00	25.00	20.00	33.00
Fertilizer - Nitrogen***	18.00	18.00	3.00	3.00	3.00
- Phosphorous	7.50	7.50	12.00	12.00	12.00
- Potash	3.00	3.00	3.00	3.00	3.00
- Sulphur	2.50	2.50	2.50	2.50	2.50
Herbicides	19.00	19.00	30.00	30.00	30.00
Hail/Crop insurance	5.50	6.00	7.00	7.00	7.00
Fuel, oil and lube	9.50	9.00	9.00	9.00	9.00
Machinery repairs	7.00	7.00	9.00	9.00	9.00
Custom work	1.50	1.50	1.50	1.50	1.50
Hired labor	3.00	3.00	3.00	3.00	3.00
Building repairs	1.00	1.00	1.00	1.00	1.00
Operating interest	3.58	3.62	4.24	4.04	4.56
(D) Total cash expense	**93.08**	**94.12**	**110.20**	**105.04**	**118.56**
(E) Return over cash expense (C-D)	**74.92**	**73.88**	**81.01**	**129.56**	**87.24**
Non Cash Expenses					
Land taxes	4.00	4.00	4.00	4.00	4.00
Insurance	2.50	2.50	2.50	2.50	2.50
Utilities	2.00	2.00	2.00	2.00	2.00
Depreciation	25.00	25.00	25.00	25.00	25.00
Operator labor	10.00	10.00	10.00	10.00	10.00
(F) Total crop expense	136.58	137.62	153.70	148.54	162.06
Return to investment (C-F)	31.42	30.38	37.51	86.06	43.74

* Yields are based on trials conducted by the Alberta Pulse Growers Commission - Zone 3. These yields may not apply to other areas of the province.

** The projected price is based on price used in Alberta Agriculture, Food and Rural Development (AAFRD) '1998 Crop Projections' bulletin

*** No nitrogen fertilizer was applied to cereals following a pulse crop, or to pulse crops (small amount of N applied with fertilizer blend).

Pulse crop production costs and returns per acre

Update 1998	Crops seeded on pea stubble		Crops seeded on lentil stubble		Crops seeded on fababean stubble	
Revenue	**Barley**	**Wheat**	**Barley**	**Wheat**	**Barley**	**Wheat**
(A) Average yield (bu./ac.)*	75	37	63	28	57	39
(B) Projected price ($/bu.)**	2.40	4.00	2.40	4.00	2.40	4.00
(C) Revenue (AxB)	**180.00**	**148.00**	**151.20**	**112.00**	**136.80**	**156.00**
Cash Expenses						
Seed	12.00	13.00	12.00	13.00	12.00	13.00
Fertilizer - Nitrogen***	3.00	3.00	3.00	3.00	3.00	3.00
- Phosphorous	7.50	7.50	7.50	7.50	7.50	7.50
- Potash	3.00	3.00	3.00	3.00	3.00	3.00
- Sulphur	2.50	2.50	2.50	2.50	2.50	2.50
Herbicides	19.00	19.00	19.00	19.00	19.00	19.00
Hail/Crop insurance	5.50	6.00	5.50	6.00	5.50	6.00
Fuel, oil and lube	9.50	9.00	9.50	9.00	9.50	9.00
Machinery repairs	7.00	7.00	7.00	7.00	7.00	7.00
Custom work	1.50	1.50	1.50	1.50	1.50	1.50
Hired labor	3.00	3.00	3.00	3.00	3.00	3.00
Building repairs	1.00	1.00	1.00	1.00	1.00	1.00
Operating interest	2.98	3.02	2.98	3.02	2.98	3.02
(D) Total cash expense	**77.48**	**78.52**	**77.48**	**78.52**	**77.48**	**78.52**
(E) Return over cash expense (C-D)	**102.52**	**69.48**	**73.72**	**33.48**	**59.32**	**77.48**
Non Cash Expenses						
Land taxes	4.00	4.00	4.00	4.00	4.00	4.00
Insurance	2.50	2.50	2.50	2.50	2.50	2.50
Utilities	2.00	2.00	2.00	2.00	2.00	2.00
Depreciation	25.00	25.00	25.00	25.00	25.00	25.00
Operator labor	10.00	10.00	10.00	10.00	10.00	10.00
(F) Total crop expense	**120.98**	**122.02**	**120.98**	**122.02**	**120.98**	**122.02**
Return to investment (C-F)	**59.02**	**25.98**	**30.22**	**-10.02**	**15.82**	**33.98**

* Yields are based on trials conducted by the Alberta Pulse Growers Commission - Zone 3. These yields may not apply to other areas of the province.

** The projected price is based on price used in AAFRD '1998 Crop Projections' bulletin

*** No nitrogen fertilizer was applied to cereals following a pulse crop, or to pulse crops (small amount of N applied with fertilizer blend).

Comparing Rotations

A good crop rotation is made up of a sequence of crops that are agronomically suitable (disease control, cultural practices, etc.) **and** provide a higher overall profit. Profits can be compared based on the net return per rotation acre, or the average profit or loss per acre, per year for a particular crop rotation. Worksheet #2 is designed to help you examine the potential profitability of different rotation scenarios for your farm.

Step 1 – Adjust the Crop Budget for the Crops to be Compared

The crop budgets in this planner are based on estimated costs and returns, so you may want to adjust the costs to reflect your farm. Worksheet #1 is provided for adjusting the budget for each crop in the rotations you want to compare.

Worksheet 1. Use this worksheet to adjust the budget for your farm costs

	Crop:	Crop:	Crop:	Crop:	Crop:
Revenue					
(A) Average yield (bu./ac.)*					
(B) Projected price ($/bu.)**					
(C) Revenue (AxB)					
Cash Expenses					
Seed					
Fertilizer - Nitrogen***					
- Phosphorous					
- Potash					
- Sulphur					
Herbicides					
Hail/Crop insurance					
Fuel, oil and lube					
Machinery repairs					
Custom work					
Hired labor					
Building repairs					
Operating interest					
(D) Total cash expense					
(E) Return over cash expense (C-D)					
Non Cash Expenses					
Land taxes					
Insurance					
Utilities					
Depreciation					
Operator labor					
(F) Total crop expense					
Return to investment (C-F)					

* Yields are based on trials conducted by the Alberta Pulse Growers Commission - Zone 3. These yields may not apply to other areas of the province.

** The projected price is based on price used in AAFRD '1998 Crop Projections' bulletin

*** No nitrogen fertilizer was applied to cereals following a pulse crop, or to pulse crops (small amount of N applied with fertilizer blend).

Step 2 – Calculate the Average Returns per Rotation Acre

Use Worksheet #2 below to list the different crop rotations you are considering. Show the complete rotation from the first year to the last year. Use the adjusted crop budgets for your farm to calculate the average return per rotation acre for each rotation considered.

Worksheet 2. Crop rotation returns

	Example		Rotation 1		Rotation 2		Rotation 3	
	Crop	Return $/acre	Crop	Return $/acre	Crop	Return $/acre	Crop	Return $/acre
Year 1	Barley	31.42						
Year 2	Pea	37.51						
Year 3	Wheat	25.98						
Year 4	Pea	37.51						
Year 5	Barley	59.02						
Year 6	Barley	31.42						
Total Returns		222.86						
Years in Rotation		6						
Return/ Rotation Acre		37.14						

Inoculation of Pulse Crops

Dry bean, fababean, field pea, lentil, chickpea and lathyrus are all annual legume crops capable of obtaining a substantial portion of their nitrogen from the air. This is called nitrogen fixation and is possible because of a partnership between the legumes and soil micro-organisms known as *rhizobia*.

This partnership results in root nodule formation and is beneficial for both the legumes and the *rhizobia*. The legume supplies the *rhizobia* with sugars and mineral nutrients, while the *rhizobia* provide the legume with nitrogen.

The partnership of legume and *rhizobia* costs the legume large amounts of energy to feed the *rhizobia*. If any amount of available nitrogen is present in the soil, the plant will prefer to use it rather than supply the extra energy for nitrogen fixation.

Several observations have been made about the partnership of legume and *rhizobia*:

- application of nitrogen fertilizer with pulses results in a reduction in nitrogen fixation and nodulation, which can often lead to a yield loss, according to research done across Alberta (Table 10)

Table 10. Effect of increasing rates of nitrogen fertilizer in field pea

How yield, protein and nitrogen fixation in field pea are affected by the addition of nitrogen fertilizer.

N Rate (kg/ha.)	Nodulation Rating (0-8)	Yield (bu./ac.)	Protein (%)	Nitrogen Fixation (kg N/ac.)
0	6.1	62	17.6	82
20	5.2	62	17.6	80
40	4.7	62	17.4	68
80	3.4	62	17.3	50
Significance	sig	ns	ns	sig

- in a cool, wet spring, the growth of *rhizobia* is slowed, and plants may not be able to obtain sufficient N from the soil, resulting in a nitrogen deficiency – in soils very deficient in soil N, an application of up to 20 lb./ac. of N fertilizer may be a good investment

- each type of legume requires a specific strain of *rhizobia* (i.e. *rhizobia* that infect pea will not infect dry bean), so it is important to ensure the proper strain of *rhizobia* is used with each type of pulse crop grown
- some *rhizobia* occur naturally in soils, but it is important to add inoculant when seeding a pulse crop to make sure enough of the correct strain of highly effective *rhizobia* are present when the seed germinates
- inoculant contains live *rhizobia* and can therefore be killed by exposure to antibiotics, some fungicides, high concentrations of phosphate fertilizer, heat, drying or sunlight
- inoculant should be used before the expiry date and stored under refrigeration if not used immediately (but prevent the inoculant from freezing)

Types of Inoculants

There are three main types of inoculants – powdered, liquid and granular. The powdered and liquid forms have been the most popular, but the convenience of granular soil inoculants is gaining popularity.

Peat powdered inoculant: a finely ground peat containing over a billion *rhizobia* per gram is applied directly to the seed with a sticker of some type. Self-stick peat products are included in this group.

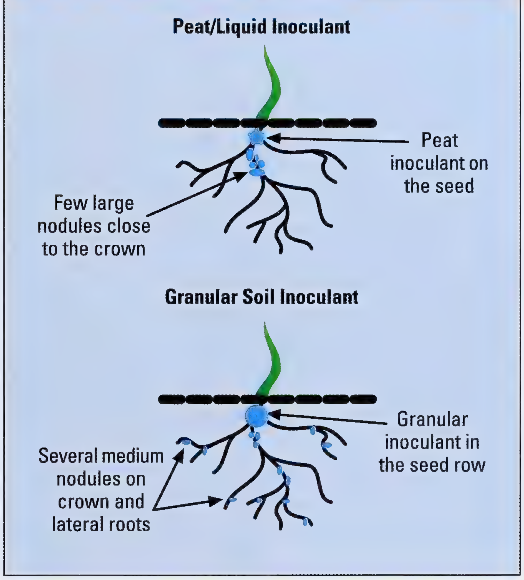
Liquid inoculant: contains the same amount of *rhizobia* as the peat powder but in a buffered liquid along with a sticker; it is also applied directly to the seed

Granular soil inoculant: made up of small peat or clay granules containing the same amount of *rhizobia* as peat powder and applied with the seed in the seed row (generally, granules are applied with the seed at a low, uniform rate of approximately 5 lb./ac., depending on the product)

Effectiveness of inoculant:

- it normally takes three to five weeks after seeding for the *rhizobia* to infect plant roots and form nodules
- effectiveness of the inoculation process can be determined by digging up plants and observing the number, size, color and distribution of the nodules
- nodules on roots should be reddish or pink inside, indicating that bacteria are functioning and fixing nitrogen
- if nodules are white, grey or greenish inside when cut in half, they are not fixing nitrogen
- distribution of nodules will vary depending on the type of inoculant used (Figure 3)
  - peat powder or liquid inoculant: nodules tend to be fewer in number, larger in size and close to the seed attachment area
  - granular soil inoculants: nodules are smaller, more numerous and distributed over the entire root system

Figure 3. Distribution of nodules on field pea roots with peat/liquid and granular soil inoculant.



Application of Inoculant

Benefits of Inoculation

There are many benefits of inoculation, but primarily, proper inoculation will ensure that little if any nitrogen fertilizer will need to be applied with pulse crops. Pulse crops contain high levels of nitrogen, and when the plant residue is returned to the soil, large amounts of nitrogen are released. As this nitrogen mineralizes, it becomes available to succeeding crops.

The highest yield potential is available when pulse crops have healthy top growth, a healthy root system and adequate nodulation. Start with a high quality inoculant, and follow all label recommendations.

It is recommended that the inoculation procedure for both liquid and peat powder be done the morning of seeding, with only as much seed inoculated as can be seeded in one day – some producers inoculate only enough seed for a half day of seeding.

Peat Powder Inoculant

- the most common type of inoculant for pulses in Canada
- to ensure even distribution, the inoculant must be stuck to the seed, so adequate *rhizobia* are close to the newly emerging roots (requires the use of a sticking agent)
- stickers can be anything that is non-toxic to the *rhizobia* and will adhere the peat powder to the seed – some examples include powdered milk, honey, corn syrup, wallpaper paste (non-toxic) or a commercial sticker
- some inoculant brands have a sticker included in the formulation
- two popular methods to stick inoculant to the seed:
  - **Sticker Solution Method**: seed is placed in a large container and sufficient sticker is applied to slightly wet the seed. The inoculant powder is applied to the seed while mixing until the seed is uniformly coated. Seed is then allowed to dry sufficiently so seeding will not be impaired.
  - **Inoculant Slurry Method**: preferred for inoculating large amounts of seed. The inoculant is premixed with the sticker in lukewarm water and then metered onto the seed as it flows through a grain auger or drill fill. Powdered fungicides such as Thiram 75WP® can also be added to this slurry solution.

Liquid Inoculant

- comes packaged in plastic bladders that allow the *rhizobia* to breath and remain healthy during storage
- bags can be hung in a convenient location and contents metered evenly onto the seed as it is augured into a truck box or through a drill fill

Granular Soil Inoculant

- applied in the seed row along with the seed
- most easily applied through a third tank on an air seeder or air drill
- can also be applied through a small seed attachment or fertilizer box on a conventional drill, but this method may result in bridging and subsequent poor distribution of the inoculant in the seed row
- manufacturer's recommendations should be followed for application rates for different crops
- research is being carried out on mixing of soil inoculant with fertilizer, a practice not recommended at this time because of damage to *rhizobia* from the fertilizer

Inoculant Testing Program

- the Legume Inoculant and Pre-Inoculated Seed Products Testing Program (Canadian Food Inspection Agency) ensures that high quality inoculants are available to pulse growers
- tests are conducted annually on samples of all products to determine if inoculants meet the standard minimum number of *rhizobia* per seed when applied at the manufacturer's recommended rate
- results are published annually and are available from:
  Canadian Food Inspection Agency
  Food Inspection Directorate
  Plant Products Division, Fertilizer Section
  59 Camelot Drive
  Nepean, Ontario K1A 0Y9

Nutrients Removed From Soil by Pulse Crops (lb./ac.)

Crop	Crop Part	N	P_2O_5	K	S	Ca	Mg	Cl	B	Cu	Fe	Mn	Zn
Field pea 50 bu.	Seed	120	35	40	8	15	7	3	0.03	0.04	0.2	0.1	0.01
	Straw	40	10	120	6	40	8	5	0.01	0.02	0.4	0.3	0.01
	Total	160	45	160	14	55	15	8	0.04	0.06	0.6	0.4	0.02
Fababean 44 bu.	Seed	134	32	39	6								
	Straw	48	11	47	4								
	Total	182	43	86	10								
Dry bean 30 bu.	Seed	110	45	35	7	20	15	3	0.08	0.04	0.3	0.05	0.05
	Straw	40	15	105	3	45	15	5	0.02	0.01	0.7	0.15	0.05
	Total	150	60	140	10	65	30	8	0.1	0.05	1.0	0.2	0.1
Lentil 30 bu.	Seed	61	19	32	5								
	Straw	31	6	44	5								
	Total	92	25	76	10								

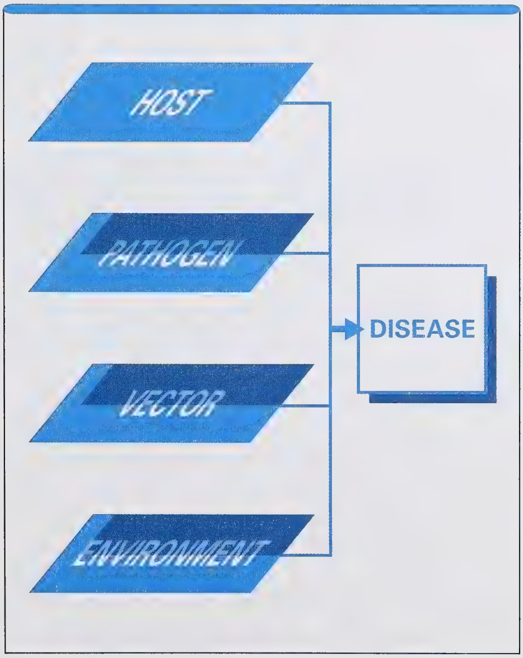
Practical Disease Control in Pulse Crops

The acreage of pulses in western Canada has increased steadily in recent years, mostly due to new markets, processing and the suitability of pulses as "break crops" in cereal cropping.

Diseases present a challenge to the pulse grower and can result in substantial yield loss, harvest problems and reduction in seed quality. "Disease" is defined as a disturbance in the plant function accompanied by the appearance of symptoms (either to a part of, or the whole plant). A pulse disease is complex in that it only occurs as a result of the interaction among the pathogen, the pulse host and environmental conditions conducive to disease development.

Since many factors must occur to actually develop a serious economic outbreak, disease detection, prevention and control in pulse crops can be difficult. In many cases, the disease (such as ascochyta blight in pea crops, powdery mildew in pea crops or sclerotinia) is present in the field, but the absence of environmental factors means an outbreak does not occur.

The following diagram illustrates the complexity of diseases and the many factors involved.



Causes of Plant Diseases

Diseases are caused either by unfavorable conditions in the environment (non-infectious disease) or by micro-organisms (infectious disease or "spreading" disease).

Some causes of non-infectious disease:

- low temperature (frost or chilling injury)
- high temperature (sun scald)
- chemical injury (herbicide drift and injury)
- lack or excess of nutrients
- excess water
- toxic soil conditions (high alkalinity or salinity)
- a combination of the above

Infectious diseases are caused by:

- fungi
- bacteria
- viruses

Not all diseases affect all pulse crops, and not all diseases are of economic importance at this time in Alberta. The following major diseases in pulse crops are shown to cause economic losses:

Lentil: ascochyta, anthracnose, botrytis, root rots

Field Pea: ascochyta complex is the main one although seedling blights, root rots and powdery mildew can cause problems

Fababean: botrytis is the main disease

Dry Bean: sclerotinia stem rot (white mold), root rot and seedling blight

Chickpea: ascochyta is most severe followed by botrytis

The chance of a disease problem occurring increases as more acres of a particular species are grown in an area.

General Methods of Controlling Plant Diseases

Control of diseases is most effective when growers use an integrated disease management system that includes:

1. good knowledge of the disease and the life cycle of the organisms that cause diseases, combined with aggressive field scouting
2. use of disease-free, high-germinating, high-vigor seed
3. sound production agronomy
4. use chemical disease control when necessary

1) Good Knowledge

You do not have to be an expert in pulse crop diseases, but you should try to read information available to develop your skills in recognizing symptoms. Diagnosis is possible through a grower's own observations, and most problems can be identified through a persistent **field scouting** program. Early diagnosis is essential so timely and appropriate control measures can be applied.

Some tips on field scouting and diagnosis:

- Examine all the facts at hand. Look for clues in cultural practices and growing conditions. Do not assume that an infectious disease is the cause.
- Know the crop. Many diseases (especially non-infectious ones) can be prevented if you have a sound knowledge of growth characteristics, nutritional requirements and environmental conditions required for optimum growth.
- Learn to recognize signs of insect infestations. These can be easily confused with symptoms of certain diseases (cutworm versus seedling decay).
- Use close observations. Look at symptoms close up to determine the general type of disease (leaf spot, root rot, etc.).
- When in doubt, seek help. Certain diseases must be detected very early if chemical control is going to be successful (ascochyta - Bravo®, powdery mildew - Kumulus DF®).
- Don't give up. Don't relax until a complete diagnosis is obtained.

Prior to implementing an integrated disease program, ask yourself the following questions:

- Can anything be done now?
- Is the injury enough to warrant a control program?
- Is spraying worth while when foliage is heavily infected?
- What equipment is necessary for control?
- What are the costs associated with a control program?
- Does the pathogen persist in the soil for many years?
- Will the disease recur?
- Could injury have been avoided by seeding resistant varieties?

2) Variety and Seed Considerations

The most effective way to manage diseases is by prevention – a grower's best defense is to use resistant varieties.

A major goal in plant breeding has targeted powdery mildew in pea and ascochyta blight in lentil and chickpea.

Other seed considerations include using high-quality seed that is disease-free and has high-vigor and high-germination.

3) Sound Agronomy with Crop Rotations

Including pulses in cereal rotations breaks the disease cycle of cereal leaf diseases. Proper rotations are also important for disease control in pulses. As a general rule, a minimum of four years between the same pulse crop is required. However, under optimum environmental conditions, three years can suffice.

Effective crop rotations also take into consideration herbicide rotation, manure applications and nitrogen cycling.

Crop rotations have some limits when it comes to controlling soil pathogens. Diseases like damping off (*Rhizoctonia*), wilts (*Fusarium*), and root rots (*Pythium*) can live in the soil a long time.

Examples of Sound Agronomy

Any practice that produces a more vigorous and healthy plant will also discourage many kinds of disease outbreaks. Follow these agronomic principles:

- use pedigreed seed of a variety recommended for your specific area (pay attention to seed vigor and germination)
- fungicide seed treatment is especially useful for early planting in fields that have grown several pulse crops or where seedling problems have occurred. Over-handling may cause seed coat cracking, which reduces vigor
- seeding rates, row spacings, time of seeding, depth of seeding and previous tillage or zero-till can influence plant growth and tolerance to some diseases, so follow recommended practices
- use proper fertility and weed control programs
- do not roll fields when plants are wet – this includes harrowing fields for weed control in organic farming situations
- continuous field scouting from seeding to harvest is a must (but do not scout wet fields)

4) Chemical Disease Control

There are very few registered fungicides for either seed

or foliar treatments. The most up-to-date information on the use and recommended rates is available in Alberta Agriculture's **(the Blue Book) Crop Protection, Agdex 606-1**.

An integrated disease management program, including timetabled field scouting, is critical in the management of diseases in pulse crops. All tools must be available – and used when necessary – to optimize the crop profits.

Here is a summary of registered chemical products and diseases controlled:

Field Pea

Ascochyta:	Bravo 500
Pythium Seedling Blight:	Apron FL
Seedling Root, Rot Blight:	Captan, Agrox B-3, Agrox D-L PLUS, DLC
Seed Rot, Damping Off:	Apron FL, Captan FL, Thiram FL, Vitaflo 280

Dry Bean
(registration based on bean type)

Botrytis:	Benlate, Rovral
Pythium Seedling Blight:	Apron FL
Root Rot:	Captan, Ridomil MZ 72 WP
Sclerotinia:	Ronilan DF, Benlate, Rovral
Seedling Blight, Root Rot:	Agrox B-3, Agrox D-L PLUS, DLC
Seed Rot, Damping Off:	Vitavax, Vitaflo 280

Lentil

Anthracnose:	Bravo 500
Ascochyta:	Bravo 500, Crown, Vitaflo 280

Harvesting and Conditioning Pulse Crops

Pre-Harvest Management

A smooth harvest begins with proper management of the field and crop at seeding time:

- choose a field that will provide even maturity so that proper timing for harvest can be best determined – rolling or sloping fields with uneven soil moisture distribution will cause uneven ripening
- controlling weeds at the proper time will reduce cutting problems – harvest is not the time to attempt to salvage an already problematic situation

Introduction to Harvesting

Harvesting pulse crops can be a trying experience. An effective operation requires a considerable amount of management.

The harvest operation should not be considered as only the "threshing" of the crop, but rather the complete crop management required from physiological maturity to the time it is marketed. Maximum returns will be generated with crops of the highest quality and minimal quantity losses. A good harvest management system integrates cutting, threshing, drying, handling and storage to ensure maximum seed quality with minimum loss during each phase of the process.

Here are some harvest-time considerations:

- walk fields daily to determine the best time to start harvest, as many pulse crops have indeterminate growth habits – the crop can still be actively growing and flowering when the first pods begin to ripen
- harvest timing is a compromise between increased yield from younger pods and increased losses from shattering of over-mature pods – optimum time for harvest is usually before shatter losses occur
- the acceptable level of quality or quantity loss will depend on the value of the crop and the economic conditions prevailing at the time (crops destined for feed are usually of less value than seed or human consumption markets)
- carefully decide on the affordability of each portion of the harvest system – recognize the limitations of your operation and remain flexible to adapt to new technology and equipment, so you can take advantage of beneficial changes

Desiccation

If necessary, a desiccant can be used to speed uniform, quick drydown of the pulse crop and reduce the risk associated with swathing. Desiccation only speeds drying of the crop, it does not hasten maturity.

- standing desiccated crops dry more quickly after rain
- the only desiccant registered is Reglone PRO®, registered for lentil, pea and dry bean crops
- glyphosate is recommended for pre-harvest management of perennial weeds; it is not an effective desiccant
- both ground and aerial applications are licensed
- when applying a desiccant by ground, wheel tramping of high clearance sprayers will result in an average yield loss of about 1 per cent

Swathing and Straight Cutting

Most field crop harvest operations have to separate the heads or pods from the stems. Cutting has been the traditional method for doing this, but newer methods (such as the stripper header) have shown potential in some crops.

Table 11. Basic combine settings for various pulse crops

Crop	Cylinder Speed	Concave Clearance	Fan Speed	Chaffer		Cleaning Sieve	
				mm	in.	mm	in.
Pea	Low-Medium	Medium	High	15-19	5/8-3/4	6-13	3/8-1/2
Lentil	Low-Medium	Medium	Medium	13-19	1/2-3/4	6-13	3/8-1/2
Fababean	Low	Medium-High	High	15-19	5/8-3/4	6-13	3/8-1/2
Bean	Low	Medium-High	High	15-19	5/8-3/4	6-13	3/8-1/2

Cutting with a reciprocating cutter bar has been satisfactory for a variety of crops and still remains a popular and effective method. The most desirable are cutting systems adaptable to cereal, forage and pulse crops.

- as mentioned above, timing is important to minimize harvest losses and obtain high quality
- in general, pulse crops should be cut tough to reduce crop losses
- rolling after seeding makes swathing or straight cutting easier – rolling after seeding is not recommended for chickpea and is not necessary for fababean
- swathing is often used to reduce dirt and stones entering the combine, which cause excessive combine wear and earth tag of the seed
- swather or straight-cut header adjustments and modifications are often required to properly harvest pulse crops
- pick-up reels, vine lifters, increased header floatation, adjustable gauge wheels, poly skid plates and use of a floating cutter bar all aid cutting
- pick-up reel adjustment will vary with each crop and amount of lodging
- length and spacing of vine lifters varies with length of vine and type of cutter bar
- cut crop perpendicular to, or at an angle to, the crop lean

Threshing

Combining pulse crops is not significantly different from other crops. An understanding of the basics of combine performance (found in the manual) is essential to an effective harvest operation. Most producers will know that setting a combine for optimum performance in one condition does not guarantee satisfactory performance in all conditions. As weather and harvest conditions constantly change, adjustments must be made as outlined in the operator's manual.

Remember, pulse crops are highly susceptible to mechanical seed damage during harvesting:

- fine tuning adjustments depend on performance, crop and weather conditions and machine type
- learn to recognize when performance is limited by machine design or when performance is a result of settings, adjustment, or operating techniques
- operator skill is required to maintain optimum overall productivity by balancing combine capacity, performance and efficiency
- maintain low cylinder and rotor speeds and maximum concave clearance
- adjust sieves to minimize returns as rethreshing will increase seed damage
- use high chaffer air flow – except for lentil, which can be blown out of the combine
- properly adjust elevator chains
- run unloading augers at full capacity, but low speed
- damaged seed has significantly lower survival rates than healthy seed – seed treatment may be useful in improving survival rate of pulse crops grown from damaged seed (see Table 12)

Table 12. Effect of apron seed treatment on survival of field pea in soil inoculated with *pythium ultimum* (1996, 1997) - Dr. S.F. Hwang, Alberta Research Council

	Non Damaged Seed	Damaged Seed
Survival of Apron Treated Seed	81%	78%
Survival of Non Treated Seed	40%	34%

Moisture Testing

- an accurate moisture tester is an invaluable tool to a harvest operation, as an accurate assessment of moisture content aids in determining proper threshing stage – it is a cost-effective item considering the risk associated with high moisture grain in storage
- grain conditioning systems must rely on careful monitoring of moisture conditions throughout the storage period
- Table 13 outlines the moisture classifications and conversion tables for the Canadian Grain Commission moisture meter – a complete listing is available from the Canadian Grain Commission publication *Grain Grading Handbook for Western Canada*

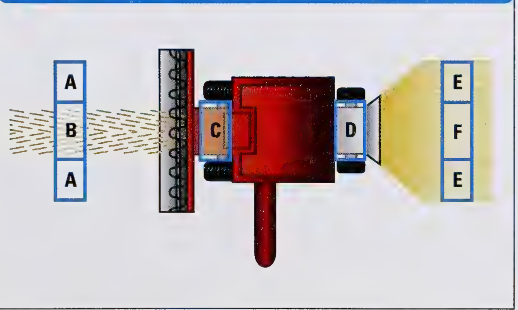
Table 13. Canadian Grain Commission moisture testing table (Model 919/3.5 moisture meter)

Grain Type	Weight (gm)	Conversion Table No.	Tough (%)	Damp (%)
Pea	250	#2 Century	16.1 to 18.0	Over 18%
Lentil	250	#1	14.1 to 16.0	Over 16%
Fababean	250	#2	16.1 to 18.0	Over 18%
Black Bean	250	#1	No Tough	Over 18%
Pea Bean	250	#2	No Tough	Over 18%

Combine Losses

An estimation of harvest losses is an important factor in determining combine performance. Checking for losses is not complicated – an analysis of crop material both before and after passing through the combine should identify problem areas (Figure 4).

Figure 4. Potential loss areas: A&B) natural and cutter bar, B) windrow losses, C) pick-up losses, D) shoe losses, E&F) rotor or walker loss



Natural and Cutter Bar Losses (Areas A & B, Figure 4)

- natural losses occur due to wind, lodging, wildlife and precipitation
- area "B" represents losses that occur after the cutter bar, but before the combine
- in shatter-prone crops, windrow losses can be significant and should be determined prior to threshing
- if a straight cut header is used, natural and cutter bar losses can be determined in area "C" – to determine losses in this area, stop the combine and count the kernels behind the cutter bar but ahead of the feeder housing

Pick-up Losses (Area C, Figure 4)

- when the crop is swathed and a pick-up attachment is used, pick-up losses will occur in area "C"
- to determine pick-up losses, stop the combine and count the kernels behind the pick-up but ahead of the feeder housing
- to identify pick-up losses, the natural and cutter bar losses must first be determined and subtracted from the pick-up loss count, otherwise the natural and cutter bar losses will be included in the pick-up loss measurements

Shoe and Walker Losses (Area D, Figure 4)

- to accurately determine shoe losses, a catch container should be used
- a pan one meter long by 250 mm wide (4 ft. x 1 ft.) works well and provides a reasonable sample size – smaller pans will work, but are subject to greater sampling error
- to assess shoe losses:
  - place the pan under the combine so material from the shoe drops into the pan as the combine passes over
  - if possible, remove the pan from beneath the combine before material from the rotor or walkers enters the pan (on some machines, or at high field speeds, this may be difficult or impractical, so walker or rotor loss must then be included in the loss measurement)
  - carefully remove straw and chaff from the pan and count the kernels – be sure to include kernels that have not been threshed from the pods

Rotor or Walker Losses (Areas E & F, Figure 4)

- collect the sample in the same manner as for the shoe losses
- place the pan on the ground after material from the shoe has dropped, but before material from the rotor or walkers drops onto the ground

- for best accuracy, the straw spreader or chopper should first be removed – losses will then be found in area "F"
- if removal of the straw spreader or chopper is inconvenient, leave the straw spreader attached but drop the pan behind the spreader
- count the kernels and be sure to include any broken or damaged kernels (this loss calculation will require an estimate of the straw spreading width)

Loss Calculations

Calculating estimated losses is a simple procedure that can be conducted by finding the source of the loss and calculating accordingly.

- if the loss is concentrated (i.e. windrow or shoe losses), you will have to account for the increase in concentration – Equation 1 can be used to estimate windrow, shoe and concentrated walker or rotor losses
- to determine losses, compare the equivalent number of evenly distributed kernels to the appropriate loss figures from Table 14
- for non-concentrated losses (i.e. natural, cutter bar and disturbed walker or rotor), you will have to estimate the straw spreading width – losses can then be calculated from Equation 2 and compared in the same manner as above to the appropriate figures in Table 14

Equation 1

$$\text{Loss} = \frac{\text{Cylinder or swath width (ft.)}}{\text{width of cut (ft.)}} \times \frac{\text{Kernels per sq. ft.}}{\text{No. of evenly distributed kernels from Table 14}}$$

Equation 2

$$\text{Loss} = \frac{\text{Width of spread (ft.)}}{\text{Width of cut (ft.)}} \times \frac{\text{Kernels per sq. ft.}}{\text{Number of evenly distributed kernels from Table 14}}$$

Example

A combine with a 50 in. (4.2 ft.) cylinder is used to harvest a pea crop that was cut with an 18 ft. swather. Nine medium-size kernels were counted in a shoe loss test. What is the shoe loss in bushels per acre?

Using Equation 1: $\frac{4.2}{18} \times \frac{9}{3} = .7\text{bu./ac.}$

Table 14. Approximate densities, kernel weights and kernel counts for various crops

Crop	Density		Kernel Weights		1000 Kernel Weight	Bushel Weight	Evenly Distributed Kernel Counts	
	kg/m³	lb./ft.³	*K/kg	*K/lb.	gm	lb./bu.	*K/m² (100 kg/ha.)	*K/ft² (1bu./ac.)
Field Pea -small	772	48	6000	2700	167	60	60	4
-medium	772	48	4400	2000	227	60	44	3
-large	772	48	3500	1600	286	60	35	2
Lentil -Laird	772	48	16000	7300	63	60	160	10
-Eston	772	48	31200	14200	32	60	312	20
Fababean	830	52	2000	900	500	64	20	1
Bean -pinto -pink -Mexican -northern	772	48	3300	1500	303	60	33	2
-small whites	772	48	5720	2600	175	60	57	4

*K=kernels

Drying, Conditioning and Storage

The main objective of proper storage is to maintain the quality and quantity of the harvested crop. The quality of pulse crops cannot be improved during drying and conditioning. At best, drying and conditioning is a method of preserving the quality at which the crop was threshed.

Maintaining quality involves controlling the activity of fungi, insects, mites, rodents and to some extent, the respiration of the seed itself. Viable seeds are a living plant material that exhibit a metabolism by which carbon dioxide, water and heat are produced. Respiration rate is a function of seed moisture content and temperature.

As temperature and moisture content increase, the rate of respiration increases exponentially. Higher temperature and moisture contents can also produce conditions that contribute to the growth of mold and pests. Controlling unfavorable conditions is best done by controlling the time, temperature and/or moisture content of the crop in storage.

Properly harvested and dried grain can be stored for a considerable time, although all grain will eventually spoil. Good management is needed to control the rate of deterioration until the seed is used.

The definition of spoilage, or the amount of acceptable deterioration, depends on the final use of the seed. For seed growers, the most important criteria is the germination vitality of the seed. For others, the criteria may be seed color, level of protein, odor or pest infestation.

Conditions can change very quickly during storage. The length of time until unacceptable levels of deterioration occur depends on the conditions at time of storage and during the storage period as well.

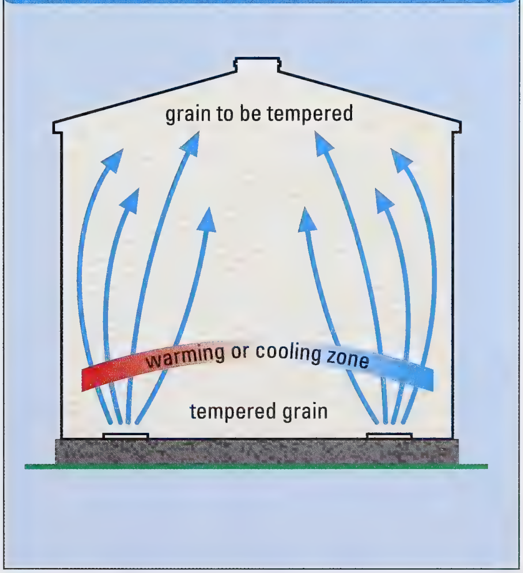
Grain conditioning is needed for the control and management of temperature and moisture conditions of the seed:

- pulse crops are often harvested tough or damp to reduce harvest losses and maintain quality – pulse crops will require further drying for safe storage
- to ensure safe, prolonged storage, pulses must be dried to less than 14 per cent moisture content and cooled to less than 15 degrees C
- temperature at time of binning affects length of time pulses can be safely stored – even dry pulses should be cooled by aeration if harvested during warm weather (usually takes less than 24 hours)
- clean the weed seed dockage out of pulses to greatly increase storage time and reduce risk of heating
- pulses take on and lose moisture more quickly than wheat or canola – minimize damage to pulse seed during drying by using low drying temperatures and cooling the seed prior to unloading from the dryer
- maximum drying temperature should be 45 degrees C for moisture contents of less than 24 per cent – for moisture contents above 24 per cent, the maximum drying temperature should be 38-40 degrees C (for seed purposes)
- if the pulse requires drying by 10 per cent moisture content or more, it will be necessary to dry in two or more separate drying operations, with 8-to-24 hours in between (depending on the seed size)
- fall cooling and spring warming of stored seed are recommended to maintain condition of seed in storage

Aeration

Aeration helps reduce storage problems by minimizing temperature and moisture variations. Aeration is not a drying system and should not be used as one. However, under ideal weather conditions some drying may occur during aeration.

Figure 5. Aeration for temperature control



Air flow rates for aeration are normally one-to-two litres of air per second per cubic metre of grain (or 0.08 to 0.16 cubic feet of air per minute per bushel of grain).

The time for one cooling or warming cycle to completely pass through grain can be estimated by the following formula:

$$\text{Number of hours to cool or warm the grain} = \frac{195}{\text{airflow rate (L/s-M3)}}$$

(or)

$$\text{Number of hours to cool or warm the grain} = \frac{15}{\text{airflow rate (cfm/bu)}}$$

Management of an Aeration System

- recommended air flow rates for aeration at 1-2 L/s-m^3 (0.08 - 0.16 cfm/bu.)
- the bin floor should be 15 per cent perforated (minimum)
- grain should be within 1 per cent of dry
- the grain should be free of foreign material and fines to decrease air flow resistance
- level the top to promote uniform air flow through the mass
- operate the fan long enough to complete a warming or cooling cycle

Fall

- grain should be cooled as quickly as possible – start aerating as soon as the grain is in the bin
- check grain temperature and turn off the fan when it is less than 5 degrees C (9 degrees F) above the outside temperature
- check grain periodically for condensation or heating
- if the grain will be kept over winter, turn the fan on again when outside temperature gets colder, and aerate until the grain temperature is less than 5 degrees C (9 degrees F) above the outside temperature
- continue cooling until the entire volume of grain is close to 0 degrees C (32 degrees F)

Winter

- after turning the fan off, cover the opening with metal, canvas or plywood to keep out rodents
- when outside temperature is close to that of the grain, run fan for a day or two

Spring

- if the grain is being held over the summer, a series of warming stages beginning in April is recommended – continue until the grain temperature is about 10 degrees C (50 degrees F)

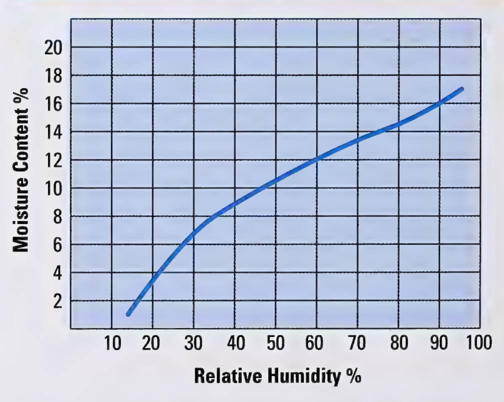
Summer

- by June, grain temperature should be 10 degrees C (50 degrees F)
- check grain periodically and run fan during cool, fair weather when outside temperature is lower than grain temperature

Natural Air Drying

- uses the drying potential of natural air to remove excess moisture from the crop
- seeds either absorb or give up moisture depending on the relative humidity of the surrounding air – the moisture content at which a product is in equilibrium with the surrounding atmosphere is called the equilibrium moisture content (see Figure 6)
- equilibrium moisture content depends on the temperature of the air, as well as the drying history of the product
- seeds dry (give up moisture) more readily than they re-wet (absorb moisture) – for this reason, it's usually not advisable to shut off natural air drying fans during rainy or high humidity periods

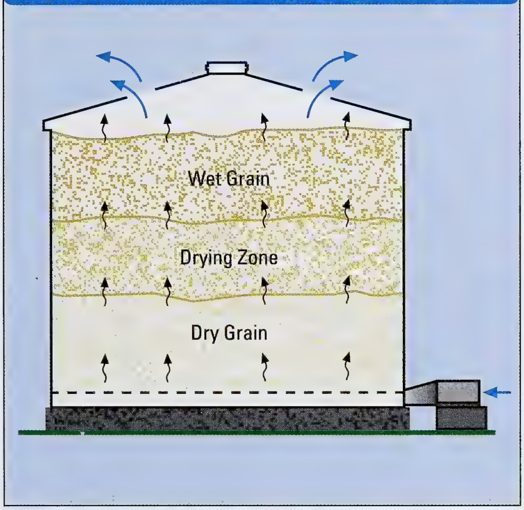
Figure 6. Approximate equilibrium moisture content of pulse crops



- air flows required for natural air drying depend on the crop, climate and moisture content, but typically, air flows should be at least 20 L/s-m^3 (1.5 cfm/bu.) to remove 4 per cent moisture
- natural air drying can be a race to dry kernels sufficiently before they deteriorate
- as air is forced into the bin, moisture evaporates and escapes out the top of the bin (Figure 7)

- as the bin begins to dry, a drying front is set up in the grain mass – grain above the drying zone remains near its initial moisture content, while grain below the drying front has a moisture content in equilibrium with the outside air conditions
- kernels located at the top of the bin are the most critical since they are the last to dry
- the more air that is delivered, the quicker the drying zone moves through the bin and the more reliable the drying system

Figure 7. A natural air drying system



- most natural air drying systems are used for cereal, oilseed and pulse crops
- the amount of air a system is capable of delivering depends on the type and size of fan, type of crop, type and size of perforate flooring, climatic conditions, method of bin filling, etc.
- pulse crops are generally a large-kernel crop, so tend to have lower air flow resistance than many other types of crops
- as a rule of thumb, if a system is designed to provide adequate air flow for small grains, it should be sufficient for pulse crops
- keep a record of air flow rates of your different natural air drying systems:
  - air flow can be estimated by using a manometer to measure static pressure
  - knowing the air flow rate can be useful during bin filling
  - a desired air flow rate (i.e. 20 L/s-m^3 (1.5 cfm/bu.)) can be achieved during bin filling by matching fan output to the grain volume
  - air delivery rates should be monitored throughout the drying period to provide a check on system performance

Management of Natural Air Drying Systems

- minimum recommended air flow rate for natural air drying of pulse crops is 20 L/s-m^3 (1.5 cfm/bu.)
- kernels should be no more than 4 per cent above dry
- the bin floor should be 100 per cent perforated (minimum of at least as large a square as possible)
- grain should be free from foreign material and fines, which decrease air flow resistance
- level the top to promote uniform air flow through the mass
- operate the fan continuously until the crop is dry, or until the outside temperature reaches close to 0 degrees C (32 degrees F), then continue fan management practices as outlined under the "Management of an Aeration System" section described earlier
- if supplemental heat is added, don't add more than required for a 5-to-10 degree temperature rise – typically this is a 5-to-8 kW (17,000 -30,000 BTU/h) heater for an average size fan
- add supplemental heat only during periods of cool temperatures and/or high humidity

Heated Air Drying

Care is needed when drying pulse crops in a heated air dryer, as large kernel crops are very prone to damage. Damage can occur as a result of handling, as well as from stress that occurs within the kernel during the drying process.

Damage is more likely to occur when the kernel is dry or nearly dry. The rate of drying increases as the temperature of the drying air increases. However, the kernel is more likely to be damaged if the temperature is too high. Heated air drying, then, becomes a trade-off between drying the kernel quickly and avoiding damage by doing so.

- during the drying process, moisture migrates from the inner to the outer portions of the kernel
- moisture moves relatively easily in high moisture kernels, and damp kernels also remain relatively cool due to the evaporative cooling that occurs when moisture is released

- as the kernel dries, the rate of moisture release decreases and temperature of the kernel increases – depending on the amount of moisture removed, it's possible the outer portion of the kernel can be drier and hotter than inner portions
- both temperature and moisture differentials within can stress the kernel to the point where damage occurs – although damage is not always visible to the naked eye, small stress cracks weaken the kernel, making it prone to mechanical damage
- high temperatures can also damage germination and alter protein makeup of the kernel – both temperature and duration in the dryer affect these qualities (germination and protein damage are not usually visible to the naked eye and are often detected later)
- prevent kernel damage by ensuring the maximum air temperature doesn't exceed maximum allowable temperatures (see Table 15)

Table 15. Maximum drying temperatures

Maximum Drying Air Temperature °C (°F)			
Crop	Seed Grain	Commercial Grain	Feed Grain
Pea	43 (110)	70 (160)	93 (199)
Bean	32 (90)	70 (160)	93 (199)
Fababean	32 (90)	70 (160)	93 (199)
Lentil	43 (110)	70 (160)	93 (199)

Note: temperatures are conditional on drying not more than 1 per cent below the safe storage moisture content, and not removing more than 4-to-5 per cent moisture in one pass through the dryer. With dryers where kernels are exposed to heat for long periods (i.e. non-recirculating batch), it's advisable to use temperatures 5-to-10 degrees lower than those listed.

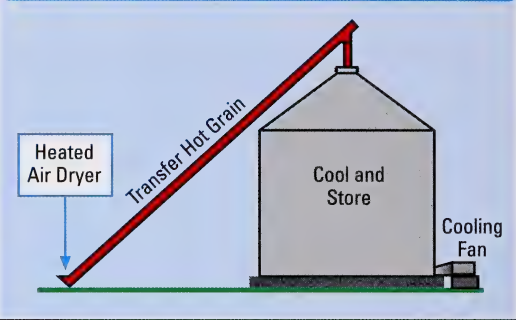
- care is needed to ensure heated air dryer conveying systems don't damage kernels, as augers, metering rolls and stirring devices can cause considerable damage to fragile crops – some dryers may be unsuitable because of this, or may need modification or alteration (avoid heated air drying altogether if the conveying system is unsuitable)

Combination Drying

Combination drying (Figure 8) is a two-stage process that uses both a heated air dryer and a natural air drying system. High moisture kernels are dried in the heated air dryer to within a few percentage points of dry, then transferred to a natural air drying bin to finish the process.

- this type of system allows the cooling section or phase of the heated air dryer to be eliminated
- kernel quality is generally better with this type of system, due to minimized kernel stress-cracking and damage that sometimes develops in final stages of heated air drying and cooling – the kernel is then less susceptible to damage during subsequent handling operations

Figure 8. Combination drying



- depending on the bin arrangement and handling system, hot, moist crops transferred to a natural air drying bin can either be cooled immediately or left to steep for a few hours
- if left to steep, kernel temperature and moisture differentials tend to equalize, which reduces kernel stress (when fans are turned on, approximately 1-to-2 percentage points of moisture will be removed)
- a considerable amount of moisture is removed with this type of system, so take care to avoid condensation problems, which increase the chance of spoilage (ensure condensation on bin roof and walls doesn't drip back into the bin)
- if condensation is a problem, avoid the steeping process and cool the crop immediately as it enters the bin, and continue to operate fans until all kernels are dry and cool (manage the natural air drying system as outlined in the above section Management of Natural Air Drying Systems)

Grain Handling System

Store pulse crops in bins equipped with a conditioning system. Aeration or natural air drying fans are necessary for safe long-term storage. Use properly constructed and maintained structures made of wood, concrete or steel, which are all suitable for pulse crops.

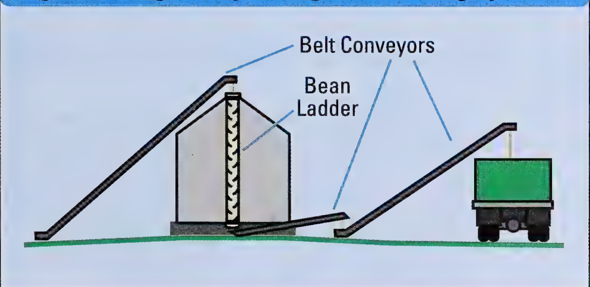
When bin filling, use these tips to reduce damage to fragile crops caused by free-fall:

- for tall bins (with a free-fall greater than 3 m/10 ft.), use an open-type bean ladder (Figure 9) to reduce damage
- open-type bean ladders use a series of zig-zag baffles to reduce kernel velocity, and two sides of the rectangular open-type bean ladder are open to allow kernels to escape and fill the bin

When unloading the bin, use equipment that provides gentle handling of the crop:

- beneath floor belt conveyors are desirable for handling fragile crops with minimal damage (see Figure 9)
- enclosed type screw augers should be avoided
- portable open type screw drag augers can be used as they are operated at slow speeds
- belt conveyors or bucket elevators should be used to elevate the crop for loading
- in large horizontal storage structures (i.e. quonsets) a tractor-mounted front-end loader can be used to load fragile crops (use care when filling the bucket to reduce crushing)

Figure 9. Fragile crop storage and loading system



Crop Handling

Mechanical damage during harvesting, conditioning and handling is a major problem in the seed industry, especially for fragile, large-kernel crops. Injury symptoms take several forms:

- gross damage to the seed coat that is easily visible such as "splits" and seed coat cracks
- internal damage visible only after seed germination
- microscopic breaks, especially of the seed coat, that reduce performance and increase susceptibility to microorganisms
- cryptic (hidden or internal) injury, which is probably physiological in nature, reduces germination vigor, lengthens the time to maturity and reduces yield

Kernel injury occurs from many kinds of abuse. When threshing, abuse is probably the most serious, while seed conditioning and handling can also contribute to injury. The effect of individual kernel impacts is cumulative in the total damage, so it is essential to always minimize impact damage to reduce total damage

- susceptibility to mechanical injury increases as the seed moisture content decreases (safe-handling moisture contents vary depending on variety)
- large kernels are particularly sensitive – excessive injury can occur at moisture contents below 15 per cent (small kernels tend to be less sensitive)

The acceptable limit of seed injury will depend on the final use of the crop:

- crops for feed processing are generally allowed higher amounts of damage – often, conventional cereal and oilseed conveying equipment is satisfactory for this purpose
- crops intended for non-feed markets need proper conveying equipment to reduce kernel injury – a "seed-quality" pulse crop can easily be reduced to "feed-quality" with just one pass through an inappropriate conveying system

Growers just getting into pulse crop production may not have proper conveying equipment. While some pulse crops can be handled effectively with conventional screw auger conveying equipment, others cannot.

Producers growing fragile crop without proper conveying equipment can use a tractor-mounted front-end loader. Dump the grain collected from the combine onto a shop or quonset floor, and use a front-end loader to push or load the seed into a pile. Although not the most efficient conveying system, it provides a reasonable method while keeping damage to a minimum. More efficient conveying systems should be obtained as the handling system develops.

Augers and Flight Conveyors

Auger and chain and flight conveyors are generally not desirable for handling fragile crops. Some crop types and varieties that are not as prone to damage can be conveyed with augers or flight conveyors within acceptable limits of kernel damage.

Keep in mind that auger and flight conveyors result in higher amounts of kernel damage than other types of conveying systems.

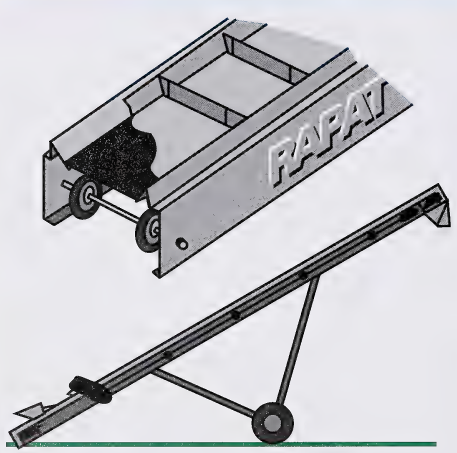
If either type of conveyor has to be used, operate the conveyor at reduced speed and keep the conveyor as full as possible. Remember that significant kernel injury occurs at lower moisture contents. Bristles can help reduce injury resulting from screw conveyors, but tend also to reduce capacity.

Belt Conveyors

Belt conveyors should be used to move fragile crops in and out of storage. Belt conveyors are generally more expensive than other types of conveyors, but result in the lowest kernel injury.

Flat belts, molded rubber flight belts and belt-in-a-tube conveyors are available from several manufacturers. Portable types (Figure 10) are available in different lengths and configurations. Tube conveyors offer all-weather protection for both the belt and the product. Molded rubber types are easier to clean while the self-cleaning bed feature offered by some manufacturers helps reduce debris build-up beneath the belt. Belt conveyors with molded rubber flights can elevate grain to an elevation angle of 45 degrees without cracking or grinding. Non-molded types are generally limited to an elevation angle of 10 degrees.

Figure 10. Belt conveyor with molded rubber flights



Pneumatic Conveyors

Caution is advised when using pneumatic conveyors to convey fragile pulse crops. Pneumatic conveyors typically use air velocities ranging from 15 to 25 m/s (3000-5000 ft./min.), which can cause significant kernel damage due to abrasion and impact on system walls and components. Rotary air lock feeders can also cause considerable injury to fragile kernels.

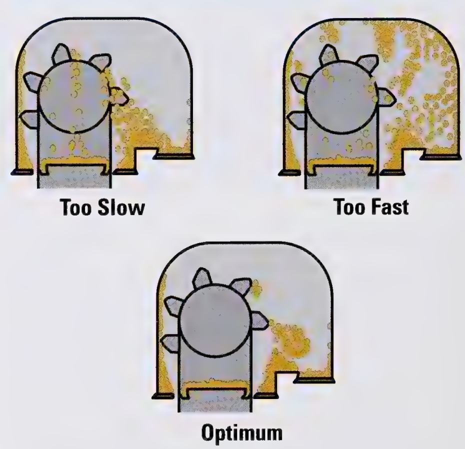
The use of lower conveying air speeds and abrasion-resistant liners may reduce kernel damage, but generally pneumatic conveyors are not advised for fragile pulse crops.

Centrifugal Bucket Elevator

Most bucket elevators used in the grain industry are the centrifugal discharge type, which work well for most crops but can cause damage to fragile crops. Proper adjustment of the elevator is needed to reduce chance of seed damage.

Belt speed is the most critical factor in causing seed damage. Belt speed should be just sufficient to throw all kernels into the discharge spout (Figure 11), or they will be subject to damage when they fall back down the leg. (Kernels thrown too fast hit the head shield and fall back, while some kernels thrown too slowly don't make the discharge spout.)

Figure 11. Elevator head speeds



Proper belt speed depends on the head pulley speed, the head pulley diameter and the design of the buckets. Head pulley and belt speeds should not exceed the maximum recommended speeds for the various head pulley sizes as shown in Table 16.

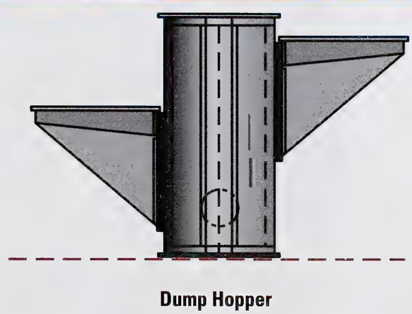
Table 16. Recommended head pulley and belt speeds for various head pulley sizes

Head Pulley Diameter mm (in.)	Head Pulley Speed (RPM)		Belt Speed m/s (ft./min.)	
	Recommended	Maximum	Recommended	Maximum
229 (9)	77	100	.92 (182)	1.20 (236)
305 (12)	66	92	1.05 (207)	1.46 (288)
406 (16)	59	82	1.25 (247)	1.74 (343)
457 (18)	56	78	1.34 (264)	1.87 (368)
610 (24)	50	70	1.60 (314)	2.23 (439)
914 (36)	10	56	1.92 (377)	2.68 (528)

Proper loading of a centrifugal bucket elevator is important. Following is the most efficient method of filling the buckets and reducing chances of spillage and damage:

- dry, free-flowing materials should enter the upside of the elevator if at all possible
- the bottom line of the feed hopper should be higher than the horizontal projection of the boot pulley shaft center line (Figure 12) – in other words, kernels should be fed into the cups when the cups are moving upwards, rather than when the cups are still in contact with the boot pulley
- this also reduces power requirements by eliminating the "dredging effect" which occurs when the elevator is loaded near the bottom

Figure 12. Proper hopper location



Positive (or Perfect) Discharge Elevators

These elevators (Figure 13) have buckets mounted at intervals between two strands of chain, and buckets are loaded by direct feeding on the upside of the leg or by scooping material from the boot. Positive discharge elevators operate at low speeds and are designed to completely discharge the bucket contents. These

Figure 13. Positive discharge elevator

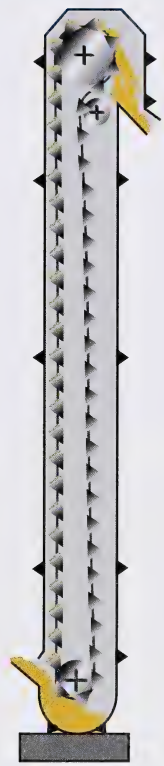
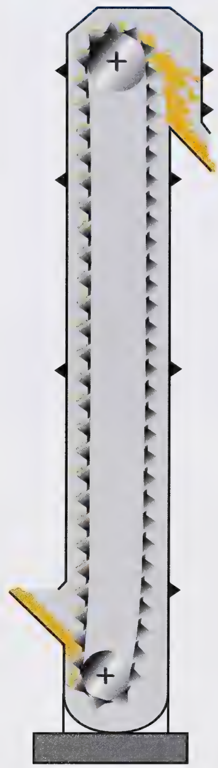


Figure 14. Continuous bucket elevator

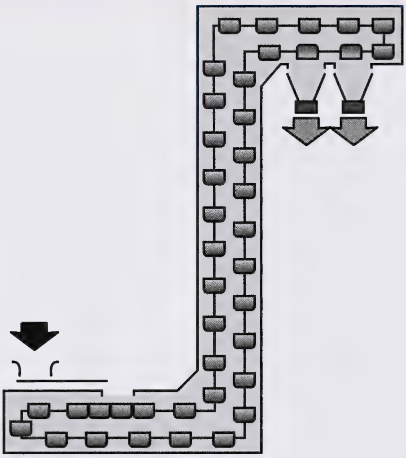


elevators are useful when handling light and fragile kernels, which do not otherwise discharge readily from centrifugal bucket elevators.

Continuous Bucket Elevators

These elevators have buckets mounted as close together as possible, either on a belt or a chain (Figure 14), and buckets discharge by gravity as they pass over the head pulley or sprocket. Kernels are directed into the discharge spout by a chute formed by the preceding bucket. Continuous bucket elevators should only be loaded by direct feeding on the upside of the leg. This reduces power requirements and reduces damage. Due to the close bucket spacing, continuous bucket elevators can attain high capacities with slow belt speeds.

Figure 15. Combination bucket elevator



Combination Bucket Elevators

These elevators (Figure 15) are specifically designed to handle fragile products since specially-designed buckets are suspended on slow moving chains. A lip on each bucket allows the elevator to be fed continuously. Since the kernels are fed directly into slow moving buckets, damage is reduced. Kernels are discharged when the buckets are overturned over a discharge chute.

Although combination bucket elevators are expensive and require more floor space than other types of elevators, they can be more economical when handling large quantities of fragile seed. Other advantages:

- the design allows them to transport material both horizontally and vertically (maximum practical transporting distances are about 30 m (100 ft.) horizontally and about 15 m (50 ft.) vertically)
- they are self-cleaning, eliminating seed lodging between buckets and belt, a common problem with other types of bucket elevators – especially desirable for seed growers where contamination is a concern

Spouting

Kernel damage often results from excessive velocity followed by impact. Spouting can be the cause of high seed velocity since long, steep spouts increase kernel velocity and thus the possibility of kernel damage. Table 17 shows approximate kernel velocity resulting from various spout lengths and pitches. As a rule of thumb, maximum kernel velocity should not exceed 7.6 m/s (1500 ft./min.).

The high velocity of kernel spouting (and resulting damage) can be reduced by installing flow-retarding devices:

- **short spouts with steep pitches**: to reduce kernel velocity, install an enclosed bean ladder instead of the standard round spouting, so kernels flow through the ladder in a zig-zag fashion
- long down-spouts: a flow retarder (Figure 16) will reduce kernel velocity but not spout capacity – typically, flow retarders are used on slopes greater than 45 degrees and are usually placed every 6 to 10 m (20 to 30 ft.) (steeper slopes require closer and more frequent spacings)

By reducing kernel velocity, flow retarders not only reduce kernel damage, but also reduce down-spout wear, making them an economical choice when compared to the cost of replacing worn down-spouts. Flow-retarders are also self-cleaning and don't require servicing.

Figure 16. A grain flow retarder

Table 17. Kernel velocities for various spout angles and lengths

Kernel Velocities m/s (ft./min.)

Spout Length m (ft.)	Spout Angle						
	35	40	45	50	55	60	90
1.5 (5)	2 (400)	2.7 (524)	3.1 (618)	3.6 (700)	3.9 (770)	4.2 (830)	5.5 (1075)
3.0 (10)	2.9 (570)	3.8 (742)	4.4 (875)	5.0 (990)	5.5 (1090)	6.0 (1180)	7.7 (1520)
4.6 (15)	3.5 (696)	4.6 (908)	5.4 (1070)	6.1 (1210)	6.8 (1335)	7.3 (1440)	9.4 (1860)
6.1 (20)	4.1 (805)	5.3 (1047)	6.3 (1235)	7.1 (1400)	7.8 (1540)	8.5 (1665)	10.9 (2150)
7.6 (25)	4.6 (899)	5.9 (1107)	7.0 (1380)	7.9 (1560)	8.8 (1725)	9.4 (1860)	12.2 (2400)
9.1 (30)	5.0 (985)	6.5 (1280)	7.7 (1510)	8.7 (1710)	9.6 (1890)	10.4 (2040)	13.4 (2635)
12.2 (40)	5.8 (1135)	7.5 (1480)	8.9 (1750)	10.0 (1975)	11.1 (2180)	12.0 (2355)	15.4 (3040)
15.2 (50)	6.6 (1270)	8.4 (1655)	9.9 (1950)	11.2 (2210)	12.4 (2440)	13.4 (2635)	17.3 (3400)
18.3 (60)	7.1 (1390)	9.2 (1810)	10.9 (2140)	12.3 (2420)	13.6 (2670)	14.6 (2880)	18.9 (3720)
21.3 (70)	7.6 (1500)	10.0 (1960)	11.7 (2310)	13.3 (2615)	14.6 (2880)	15.8 (3110)	20.4 (4025)
24.4 (80)	8.2 (1605)	10.6 (2090)	12.3 (2470)	14.2 (2795)	15.6 (3080)	16.9 (3330)	21.8 (4295)
27.4 (90)	8.7 (1705)	11.3 (2220)	13.3 (2620)	15.0 (2960)	16.6 (3275)	18.0 (3535)	22.9 (4500)

Value-Added Opportunities for Pulse Crops

Value-adding is the selling of a product after it has been processed for more than the value of the raw product. Value-adding generates employment and other economic activity and is a priority for Alberta's agriculture industry.

- export markets, domestic wholesale markets, regional market outlets and farmers' markets all represent emerging opportunities for marketing Alberta's value-added products
- numerous products derived from pulse crops provide value-added opportunities: for example, field pea is a good source of starch, fibre, protein (particularly lysine), carbohydrate, iron, vitamins and minerals (see nutritive value of pulse crops listed in Table 18)
- field pea and derivatives can be used in primary processing, secondary processing, food processing and industrial applications – other pulse crops hold similar value-added opportunities:
  - **primary processing**: used for animal feeds as a replacement to soy meal in rations
  - **secondary processing**: conversion into starch, protein and fibre for high-value products
  - **food processing**: as ingredients for soups, salsa, chips and baked goods; as a meat or milk extender; as fibre to enrich foods, particularly those prepared in institutions
  - **industrial applications**: paper products, charcoal briquettes and pet food products

For pulse crops, most value-added processing in Alberta occurs at the primary and food processing levels. Currently, Alberta value-added pulse food products represent several different types of processing:

- dry soup mixes
- precooked and (often) canned
- precooked and frozen
- precooked and dehydrated for "instant" mixes
- milled, extruded, coated and precooked in oil to create snacks

Alberta Agriculture's Leduc Food Processing Development Centre is a pulse product development resource for processors. Contact them at:
6309 - 45 Street, Leduc, Alberta, T9E 7C5
Phone: (780) 986-4793 Fax: (780) 986-5138
website:
www.agric.gov.ab.ca/ministry/org/fpdc/index/html

Table 18. Nutritive value of pulse grains

	Measure	Wt. (gm)	H_2O (%)	Energy kcal	Energy KJ	Protein (gm)	Carbohydrates (gm)	Fat (gm)	SFA (gm)	PUFA (gm)	Cholesterol (mg)
Dry Bean: Common white cooked and drained	250 ml	189	63	263	1100	18	47	1	tr	tr	0
Dry lima cooked and drained	250 ml	199	70	228	954	15	41	1	tr	tr	0
Red kidney cooked and drained	250 ml	187	67	238	996	16	43	1	tr	tr	0
Chickpea boiled and drained	250 ml	173	60	284	1188	15	47	4	tr	2	0
Lentil cooked and drained	250 ml	209	70	243	1017	19	42	1	tr	tr	0
Soybean dry cooked and drained	250 ml	182	63	314	1314	30	18	16	2	9	0
Field Pea split and cooked	250 ml	207	69	244	1021	17	44	1	tr	tr	0

	Calcium (mg)	Iron (mg)	Na (mg)	K (mg)	Vitamin RE	Thiamin (mg)	Riboflavin (mg)	Niacin NE	Folate (mcg)	Vitamin C (mg)	Dietary Fibre (gm)
Dry Bean: Common white cooked and drained	170	7.0	11	1060	0	.22	.09	3.9	153	0	8.3
Dry lima cooked and drained	34	4.7	4	1010	0	.32	.11	3.9	165	0	6.6
Red kidney cooked and drained	52	5.5	4	754	0	.30	.11	4.3	242	2	6.7
Chickpea boiled and drained	85	5.0	12	504	5	.20	.11	3.4	298	2	6.1
Lentil cooked and drained	40	7.0	4	772	2	.35	.15	5.0	378	3	8.4
Soybean dry cooked and drained	185	9.3	2	93	2	.28	.52	8.1	98	3	8.0
Field Pea split and cooked	29	2.7	4	750	2	.39	.12	5.1	134	1	4.8

SFA = saturated fatty acids
Na = Sodium
PUFA = polyunsaturated fatty acids
K = potassium
tr = trace

The Pea Plant

Field Pea Description

Pisum sativum
(white flowered)

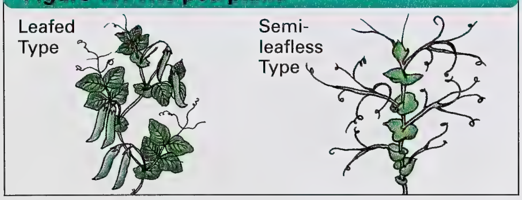
Pisum sativum spp. arvense
(purple flowers)

The common cultivated field pea is botanically classified as *Pisum sativum*, white flowered. Another type, Austrian or maple pea (*Pisum sativum* spp. arvense), has purple flowers and is grown on a small acreage for special markets.

Alberta produces both long-vined indeterminate pea types (internodes 4 to 8 in. or 10 to 20 cm long) and short-vined determinate types (1 to 3 in. or 2.5 to 7.5 cm long).

- field pea is an annual herbaceous plant with slender succulent stems 1 to 6 ft. (.3 to 1.8 m) long
- the plant normally has a single stem, but has the ability to form tillers under certain stress conditions – stresses that could cause tiller growth include early-season frost, hail, cutworm damage or moist conditions following a mid-season drought (tillers that form later in the season seldom produce marketable seed)
- pea foliage color is generally green to pale green
- two leaf structures characterize field pea:
  - leafed types produce a leaf consisting of one to three pairs of leaflets and simple branched terminal tendrils
  - semi-leafless types have no leaflets on the leaf axil and compound tendrils that replace leaflets (semi-leafless types usually have large stipule leaves)

Figure 17. The pea plant



Indeterminate (tall) growth - long season (left)
Determinate (short) growth - short season (right)

- reproductive (flower) nodes bear either one, two or multiple flowers on peduncles that originate from the stem axis – the flowers are highly self-pollinated (most varieties in Alberta produce two flowers)
- the number of reproductive nodes produced on indeterminate types corresponds with the length of the flowering period, which may be prolonged by cool, wet weather
- more determinate varieties tend to produce reproductive nodes in a shorter period, which results in earlier maturity – these types can be severely affected by drought and heat stress during the reproductive period
- pea pods are normally 2 to 3 in. (5 to 7 cm) long and contain four to nine seeds, depending on the variety and growing conditions – crop stress (such as drought, heat, disease and nutrient deficiencies) can affect pod size and seed development
- seed shape varies by cultivar from round to angular or blocky, with a smooth or dimpled seed coat (most cultivars are round or near round in shape)
- pea seed consists of the seed coat (testa), the seed leaves (cotyledons) and the embryo axis
  - the seed coat encloses and protects the cotyledons and the embryo axis (the two cotyledons protect the embryo axis and provide nutrients during establishment)
  - the embryo axis is comprised of a rudimentary root (radicle) and a shoot (plumule)

Stages of Development

The life cycle of the pea plant has four principal stages:

- germination and emergence
- vegetative stage
- reproductive stage
- senescence (mature) stage

Germination and Emergence

- after sowing, the seed begins to absorb moisture through the seed coat and micropyle, causing the seed to swell
- germination occurs with the emergence of the root and later the shoot – both root and shoot extend, and emergence occurs when the shoot emerges above the soil surface
- soil temperature, soil moisture, seed quality and disease all affect the rate, success or lack of success of this stage

Vegetative Stage

- this stage includes the period from shoot emergence to the first reproductive node
- it starts with the scale leaves produced on the first two nodes on the stem – these scale leaves are very small and are often dropped later in the season
- the shoot continues to develop as a small hooked shoot that unfolds into the first leaf
- growth continues with the shoot developing an internode, followed by the second leaf node and so on – by this time the plant has started a very rapid growth phase where up to two nodes can develop in seven days time (herbicide application is best at the three to five-node stage)
- in the early seedling stage of leafed types, the leaves have a single pair of leaflets but as development advances, two or more pairs of leaflets grow per leaf
- the plant usually produces nine to 12 nodes during the vegetative growth stage, before the first flowering or reproductive node is produced

Reproductive Stage

- flower buds are enclosed within the leaflets of the growing point and remain enclosed until quite large; then the peduncle (flower stalk), elongates and buds emerge; flower bud petals open and the plant has its first fully opened flower
- usually two flowers form per node – they either abort or set, and small immature pods develop

Full flower, 2 flowers per node

- depending on growing temperature, it takes 7 to 10 days for the young pod to elongate fully (during this time the pod remains flat)
- physiologic maturity of the pod occurs in 24 to 30 days, followed by the transition to the dry seed stage
- the reproductive stage continues until plant senescence – the lowest pods mature first and maturity will range from the bottom to the top reproductive node

Flat pod stage

Approaching full pod stage

Senescence Stage

- this stage begins with the first pod showing complete drydown and progresses to where the entire plant (all pods and foliage) is tan colored and the seeds within the pods are hard
- the senescence stage overlaps the last vegetative growth stages
- it can be difficult to determine exactly when the field is mature and ready for harvest
- deciding when the crop is mature is critical for pre-harvest glyphosate application, desiccation with Reglone PRO® or swathing (refer to Field Pea Harvesting section for more information on desiccation and harvesting)

Adaptation

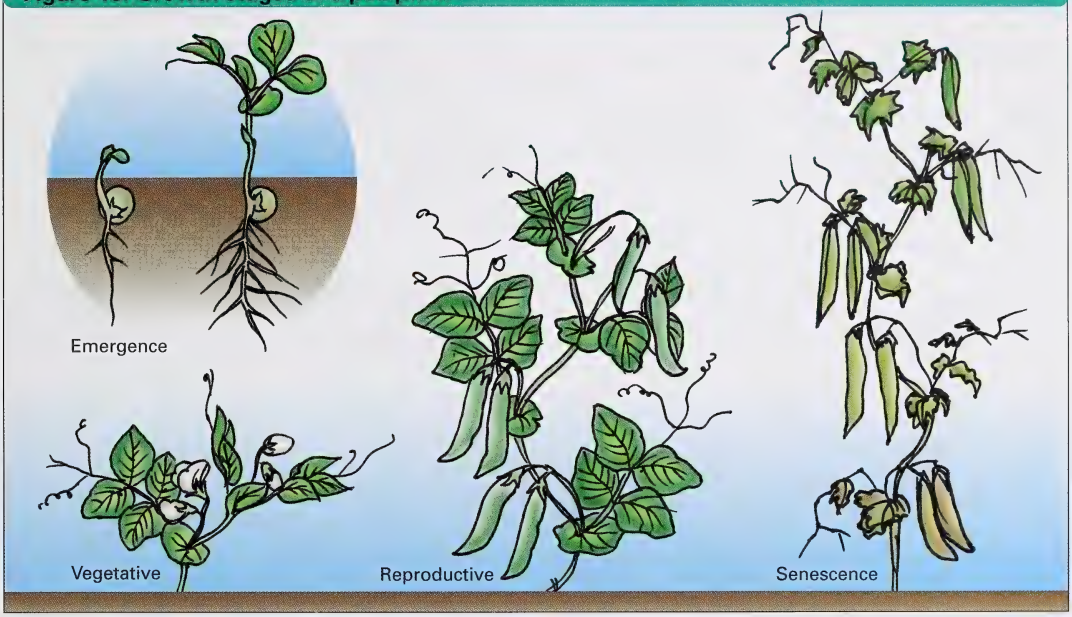
Soil, Temperature and Moisture Requirements

Field pea is considered a cool season crop that requires timely periodic moisture during its rapid vegetative growth phase and throughout its flowering period.

In Alberta, field pea is best suited to the Black and Thin Black soil zones. Successful production is also possible in the Dark Brown and Grey Wooded soil zones when proper management techniques are used.

Seed the crop as early as possible into soil that is beginning to warm (4 to 5° C) and has good structure

Figure 18. Growth stages of a pea plant



and tilth. The crop must be seeded early in May so that it has the opportunity to flower and retain most of its flowers during early July, before the heat of summer begins.

- clay loam and loam soils are best suited for field pea production
- the crop should be planted in well-drained soils that have a pH in the range of 5.5 to 7.0
- soils that are prone to water logging are detrimental to healthy pea production (cold, overly wet soils encourage seed decay and seedling rot)
- sandy soils with poor water-holding capability should also be avoided
- optimum temperatures for field pea growth are 23° C during the daytime and 10° C during the evening

Flower abortion during late July

- the crop is sensitive to drought and high temperatures during its most lush growing period, which starts at the onset of flowering – these two stressful conditions may result in some degree of flower blast, which reduces seed yield

Monitoring Crop Damage

Pea seedlings can tolerate moderate frost. Heavy frost in early spring can damage above-ground seedlings. New tillers will develop from dormant buds at the first node. The pea crop will recover but will mature later and yield less.

- moderate to heavy frost during the flowering period (or when pods are green) will cause damage and result in reduced yield and seed quality
- early-season damage by hail or wind erosion has an impact similar to frost damage, and the plant will redevelop from dormant buds within one to two weeks – do not work down a field early in the season unless it is not recovering
- pod damage due to hail ranges from a slight white blemish to a pitted area penetrating the entire pod to the seed
- when damage to the inside of the pod is visible , the pod is unlikely to fill and mature properly – the opening caused by hail will allow fungi to develop and destroy the pod, especially in moist conditions

Market Types and Uses

Most of Alberta's field pea crop is marketed as livestock feed. Feed pea prices and Alberta's cooler, shorter growing season have dictated this market over the past 15 years. Both yellow and green cotyledon types are grown for feed. Farmers who grow for the feed market will choose a variety based on its yield potential.

While most pea production is marketed for feed, higher-quality grain is marketable for a premium in the human edible food market. Most registered varieties available to Alberta producers produce grain that can be sold for food if it meets a grading standard of No. 2 Canada or better.

- provided they are relatively spherical in shape and meet other quality standards, both yellow and green cotyledon types are purchased as edible pea (the green type historically commands a higher price)
- quality and shape dictate human edible marketability first, but often buyers look for specific seed size as well as quality when sourcing for the food market (these markets usually require large to very large types, 280 to 330 gm/1000 seeds, both yellow and green)
- the marrowfat type pea is another human edible market pea. It is a very large, angular shaped green or yellow cotyledon field pea – green marrowfat peas tend to bleach very readily before harvest, so additional care is key to meeting food-quality standards
- field pea is also produced for the bird food market, though little of Alberta's pea production is used for this purpose, as bird food markets demand very specific pea types (small or very small, 130 to 160 gm/1000, seed is required or the seed must have a high tannin seed coat)


Maple type/pigeon pea

- the high tannin types are referred to as 'maple' or 'pigeon' peas – maple types are distinguishable by their purple-colored flowers (ensure the sample offered for sale is relatively clean and free of mold)

Field Pea Uses

Yellow

- split/whole for livestock feed
- split for soup
- pea flour and pea protein concentrate
- snack food/salad topping from split pea
- blend with chickpea to produce dhal
- Mexican food market for large yellow
- vermicelli noodle for China (high protein noodles)
- substitute for bean paste
- pea sprouts
- very small seed for bird food
- small seed for silage

Green

- split/whole for feed
- human consumption – whole or reconstituted and canned
- substitute for bean paste
- green noodles
- pea sprouts
- very small seed for bird food
- small seed for sliage

Marrowfat

- reconstituted and canned (mushy pea in England)
- roasted and puffed for snack food
- green pea meal by extrusion (cheezie)
- cake icing from dark green marrowfat

Maple

- preferred type for pigeon and other bird food
- pea sprouts
- long vine maple for silage use

Production Economics and Marketing

Introduction

Field pea is a crop that offers farm managers considerable flexibility in marketing. Pea can be sold to private grain companies, through the elevator system, to feed mills, hog growers and poultry producers.

The keys to obtaining the right price:

- know your costs of production
- know the pea markets you are targeting
- know the quality of pea you've grown
- understand different types of contracts
- study and use market information sources

Costs of Production

Table 19 shows production and break-even techniques that may help producers plan a marketing strategy. Start by calculating a break-even price using average yields

and a realistic estimate of production costs. Knowing the break-even price is critical to knowing when to sell, and at what price. (Costs can vary from farm to farm, so use figures from your own farm.)

In this example, if the average yield for field pea production was 40 bushels/acre, the price required to cover all the costs would be $195.65/acre costs divided by 40 bu./acre = $4.90 per bushel. If average yield is 60 bu./acre, then 195.65/acre costs divided by 60 bu./acre = $3.26 per bushel.

Table 19. Costs of production of field pea

Input		$/acre
Seed*	180 lbs. @ $.17/lb.	$ 30.00
Inoculant	dry peat with sticker @ $1/bu.	3.00
Fungicide	Thiram @ $.80/bu.	2.40
Fertilizer	Nitrogen - 8 lbs. @$.25/lb. N	2.00
	Phosphorous - 30 lbs. @ $.30/lb. P_2O_5	9.00
	Potassium - 15 lbs. @ $.20/lb. K_2O	3.00
	Sulphur - 15 lbs. @ $.15/lb. S	2.25
Herbicides	Broadleaf and Grassy weed control	26.00
Pre Harvest	Glyphosate @ $12.00/acre	12.00
Crop insurance		3.00
Fuel, oil and lube		8.00
Machinery repairs		8.00
Building repairs		1.00
Hired labor		3.00
Custom and machine rental		2.00
Operating loan interest		8.00
Direct cash costs		**$ 122.65**
Property taxes		$ 4.00
Farm insurance		2.00
Utilities (farm share)		2.00
Depreciation		15.00
Operator labor		15.00
Land rent or ownership cost		35.00
Total in-direct cash costs		**$ 73.00**
Total costs		**$ 195.65**

* seed costs can vary depending on seed size. Generally, the larger the seed, the higher the seeding rate and the higher the seed cost per acre. Smaller seeds have a lower seeding rate per acre, which suggests a lower cost for seed per acre. For example, a small seed may have a seeding rate of 125 lb./acre. At $.17 per lb., this means cost of seed is $21.25/acre. On the other hand, a large seed may have a seeding rate of 255 lb./acre. At $.17 per lb., this means cost of seed is $43.35/acre. **(refer to the section on calculating seeding rates)**

Rotational Benefit

Field pea, an annual legume, offers rotational benefits to crop production on top of its economic benefits. These include:

- reduced need for nitrogen inputs to the following crop
- higher yields of the following crop
- lower costs for herbicides and fungicides in a following crop
- a better quality crop the following year, e.g. protein premium on wheat

For more information on rotations, see Benefits of Pulses in Crop Rotations in this publication.

Market Choices

Before planting a pea crop, you'll need to identify your target market. Field pea can be marketed as:

- feed, with both yellow and green types acceptable with no price differential

Top quality yellow field pea

- human consumption, with both yellow and green according to size
- specialty pea, such as maple or marrowfat
- seed pea

Human edible pea is the premium price market for pea production. To achieve a Canada No. 2 or better, growers must provide a higher level of crop management. Pea grain must have good to natural color, be reasonably round, have minimum bleach and minimum earth tag (refer to Grade Tables 21 and 22).

Check all market information sources and market outlooks available for field pea. Consider one of the many market information newsletters, satellite information sources (DTN, Global Link), Internet web sites (STAT Publishing) and radio commentaries.

For a list of pea buyers, see www.agric.gov.ab.ca/crops/special/directory/index.html.

Producers should know that the pea market will fluctuate and storage costs may be incurred. Of course, there's no point storing field pea if the cost of storage plus the interest on the value of the stored grain does not translate into higher margins.

An alternative is to sell at harvest. The gross price per bushel may not be quite as high, but you would save the storage costs.

Quality standards in the feed market are less rigid than in the edible market. The sample must be clean, with minimal dirt and earth tag, be free of stones and have a low percentage of foreign material.

Producing pea for seed purposes requires a high level of management. Seed must be specific to the variety, and strict guidelines dictate minimal off-type material and admixtures in the sample of the pedigreed class. Seed must have high germination and vigor. Pre-harvest glyphosate herbicide cannot be used in seed pea production.

Sampling

As with any crop, it's important to know the quality of the pea you produced. Harvest-time is best for taking samples. Follow these steps:

- take the same number of cross-section samples of the grain as each load is unloaded, to provide a representative sample for each bin
- store the composite sample for each bin in a clearly marked container
- submit a representative sub-sample to determine grade and also to potential buyers

Grading services are available from grain buying companies or by sending a sample to the Canadian Grain Commission.

If you're selling feed pea, consider getting a feed analysis done on each bin and send it (with your pea sample) to all buyers of feed pea: private companies, local hog producers or feed mills. Table 20 has an example of a form you can use in marketing feed pea.

Sampling green field pea

Table 20. Sample Feed Grain Form

A quality "Alberta Grown" feed grain

Sam Brown Farms **Box 222** **Somewhere AB T0X 0X0** **Phone: 403-222-2222** **Fax: 403-333-3333** **e-mail: brown@xxxxxxxxxx**	Date listed	35913
	Alberta AGRICULTURE, FOOD AND RURAL DEVELOPMENT This form was developed by Alberta Agriculture, Food and Rural Development as a marketing tool for the wise use of Alberta feed grains. *Know what you are selling and buying.*	

Grain for sale	Amount available		Listing Price		**F.O.B. farm**	x
	Tonnes	Bushels			**Delivered**	
			$/tonne	$/bushel		
Pea	100	3675	184	5		
Grown for feed purposes from the variety			Grande			

The following is a true representation of my feed grain sample:

Moisture..............	12	%	*Dockage is mainly composed of:* barley
Protein..................	23	%	
Lysine..................	1.8	%	
Ergot....................	Nil	%	
Mold....................	Nil	%	Other Information:
Wormseed mustard................	Nil	%	
Dockage...............	3	%	
Bushel weight.......	60	lb/bu	
Uniform seed size	Yes x	No	Cereals: Thin % / Screen size

Feed grain on the Internet:	***To list*** *your feed grain on the Alberta Agriculture home site on the Internet send e-mail to faechne@agric.gov.ab.ca* ***To view*** *listings: http://www.agric.gov.ab.ca/store/contactg.html*

Table 21. Grades of green pea (Canada)*

Grade name	Standard of quality						Maximum limits of damage					
	Color	Other class	Bleached	Total other classes and bleached	Foreign material	Cracked seed coats including splits	Shriveled	Splits	Heated	Insect damage	Other damage	Total damage
No. 1 Canada	Good natural color	About 0.5%	2.0%	2.0%	About 0.1%	5.0%	2.0%	About 0.5%	Nil	About 0.3%	2.0%	3.0%
No. 2 Canada	Fair color	1.0%	3.0%	3.8%	About 0.2%	8.0%	4.0%	1 .0%	About 0.1%	0.8%	4.0%	5.0%
No. 3 Canada	Off Color	2.0%	5.0%	6.5%	About 0.5%	13.0%	8.0%	5 .0%	About 0.5%	2.5%	10.0%	12.0%

The variety or color may be added to and become part of the grade name.
*Canadian Grain Commission - Grades of Grain - August 1, 1998

Table 22. Grades of yellow pea (Canada)*

Grade name	Standard of quality				Maximum limits of damage					
	Color	Pea of other colors	Foreign material	Cracked seed coats including splits	Shriveled	Splits	Heated	Insect damage	Other damage	Total damage
No. 1 Canada	Good natural color	1.0%	Trace	5.0%	3.0%	1.0%	Nil	1.0%	3.0%	3.0%
No. 2 Canada	Fair color	2.0%	About 0.5%	9.5%	5.0%	2.5%	About 0.05%	1.5%	5.0%	5.0%
Extra No. 3 Canada	Fair color	2.0%	About 0.5%	13.0%	5.0%	5.0%	About 0.05%	1.5%	5.0%	8.5%
No. 3 Canada	Off color	3.0%	1.0%	15.0%	7.0%	5.0%	About 0.2%	4.0%	10.0%	10.0%

The variety or color may be added to and become part of the grade name.
*Canadian Grain Commission - Grades of Grain - August 1, 1998

Grading Field Pea

Color

Color as a grading factor is assessed after the removal of damaged pea and pea of other colors:

- **good color**: pea has a bright, normal color
- **fair color**: pea is moderately immature, lightly earth-tagged or stained
- **pea of other colors**: includes any whole and split pea that is obviously of another color – the separation for pea of other colors is made before separations for damaged or splits

Bleached (green pea only)

- green pea is considered bleached if 1/8 or more of the surface of the cotyledon is bleached to a distinct yellowish color, which is in marked contrast to its natural color

Cracked Seed Coats Including Splits

- applies to pea with visibly cracked seed coats and pea with all or part of the seed coat removed, including broken pea with less than 1/4 of the pea broken off (broken pea with more than 1/4 of the pea broken off are considered damaged)

Table 23. Grades of feed pea (Canada)

Grade name	Inert material	Ergot	Excreta	Small Seeds and Attrition (material through a 4.5/64 round hole sieve)	Total foreign material	Pulses other than Green or Yellow Peas	Heated
Feed Pea	1.0%	0.05%	0.02%	0.5%	6.0%	5.0%	1.0%
If specs are not met for feed pea, grade	Feed pea, sample account Canada inert material	Feed pea, sample account Canada ergot	Feed pea, sample account Canada excreta	Feed pea, sample account Canada small seeds and attrition	Feed pea, sample account total foreign material	Feed pea, sample account pulses other than green or yellow pea	Feed pea, sample account Canada heated

The variety or color may be added to and become part of the grade name.
Canadian Grain Commission - Revised April 12, 1999

- pea with cracked seed coats that are otherwise damaged are not included in the percentage by weight of pea with cracked seed coats

Damage

Damaged pea includes split or broken pea where more than 1/4 of the pea is broken off and whole pea that is sprouted, heated, shriveled, damaged by insects, badly deteriorated or discolored by weather or by disease, or that is otherwise damaged in a way that seriously affects appearance or quality.

- **insect damage**: distinctly damaged by weevil or other insects
- **splits**: includes split pea, split pea of other colors, broken pieces that are less than 3/4 of the whole seed, and halves that are loosely held together by the seed coats
- **heated pea**: pea that has dull seed coat and discolored cotyledons ranging from light tan to dark brown
- **shriveled pea**: pea whose shape is distinctly distorted, with a severely dimpled surface
- **other damage**: any discoloration or physical damage on the face of the cotyledon is considered "other damage"

In samples of yellow pea, green-colored pea (including immature yellow pea) is not considered damaged unless it is otherwise damaged; both whole and split distinctly green pea that is green throughout are considered to be pea of other colors whether the green coloring is related to immaturity or to variety. Immature pea that is not distinctly green is not considered damaged but is taken into account in the evaluation of the general color of the sample.

Feed Pea Grade

A grade schedule for feed pea was the subject of debate for some years. In 1999, that debate moved forward to a decision. The decision was made by representatives of the Canadian Grain Commission, the Alberta Pulse Growers Association, the Saskatchewan Pulse Growers Association, the Manitoba Pulse Growers Association and the Canadian Special Crops Association.

Markets will demand a cleaner standard for feed pea. The new grade for feed pea will allow the Canada industry to meet this demand. The new feed pea grade was scheduled for an August 1, 1999, implementation. The grade has a 6 per cent maximum "foreign material" tolerance. This level demonstrates the production capability and enhances the marketability of Canadian feed pea (Table 23).

Feed Pea Grading Factors

- **ergot**: is a plant disease producing elongated fungus bodies that have a purplish-black exterior, a purplish-white to off-white interior and a relatively smooth surface texture.
- **foreign material**: is any material other than pea or split pea, such as ergot, sclerotia, other grains, earth pellets, bean, lentil and chickpea. Note: in feed pea, seed coats are not to be considered as foreign material.
- **heated** - pea or split pea that have dull seed coats and discolored cotyledons ranging from light tan to dark brown - these are considered heated.
- **pulses other than green or yellow pea**: in feed pea, pulses other than green or yellow refers specifically to maple and marrowfat pea. These are not considered as part of foreign material. Other pulses such as bean, chickpea and lentil are included in foreign material.
- **total foreign material**: includes all material that passes through the #4.5 6/4 round hole sieve and all handpicked foreign material from the sample.

Contracts

One method of selling field pea is through contracting. Contracting a portion of the crop can reduce market risk. There are several types of contracts, each with advantages and disadvantages:

Production Contract

- guarantees the delivery of some or all production to a buyer
- may or may not specify the price or total volume accepted
- some production contracts specify price for a certain volume, with over-deliveries accepted only by mutual agreement between buyer and seller and priced at the market on delivery
- a date of acceptance for delivery may be specified, and some contracts will implement a storage fee to be paid to the producer after a certain date
- some seed growers or seed dealers will contract pea production for seed purposes – while these contracts can be profitable to the grower, consider the extra management required to produce high-quality seed

Deferred Delivery Contract

- also referred to as a DDC, this is an agreement to deliver a specified tonnage of a certain grade of product to the buyer by a certain date in return for a guaranteed price
- advantages to the producer of a fixed price and delivery opportunity can be considered a disadvantage later on if higher prices are offered by other buyers
- most deferred delivery contracts include escape clauses to cover the case of production failure due to adverse weather
- any contract that specifies a grade should also state how grades different from the one specified are to be handled – if other grades are accepted, the price and terms should be stated in the contract
- the contract should specify storage charges to be paid by the buyer to the seller, should the buyer delay delivery beyond that stated in the contract

Dealer or Producer Car Contract

- similar to other deferred delivery contracts except shipping is by producer-loaded railcar
- the difference between a dealer car and producer car is that the dealer car is allocated to a grain dealer, who in turn offers the railcar to a producer for loading, while the producer car is allocated directly to a producer for loading
- dealer car loaded product may have a weaker basis (i.e. lower price) than a producer car since the profit for the dealer is part of the basis – however, a dealer car often has a stronger basis (i.e. higher price) than sale of the same product through the elevator system
- some trade-offs exist between dealer/producers cars and elevator delivery:
  - delivery to the elevator is usually more convenient, involves less administration and can often provide mixing/blending benefits to improve grade
  - deliveries to an elevator can also result in immediate payment, while payment for railcar delivery is made after unload, which can be three or more weeks after the car is loaded

Basis Contract

- establishes only the delivery period and the difference that the settlement price will be compared to a specified futures month price for that commodity
- usually, the final price is determined by subtracting the basis level in the contract from the specified futures month price
- the seller may choose when to complete this pricing and can usually request a target futures price at which to trigger the pricing – most basis contracts require pricing completion sometime prior to entering the futures month specified
- once pricing is completed, the basis contract essentially becomes a deferred delivery contract
- basis contracts can be used successfully as a means of securing a price higher by locking in the basis when it is relatively strong (i.e. small discount to futures), and then completing the pricing later on, often when the futures price has risen above that available when the basis contract was signed

Target Pricing Contract

- also known as a grain pricing order or GPO, the target pricing contract is a contract where the producer/seller sets a price at which to enter into a contract for a specified quantity of product
- the contract is priced automatically if and when the price reaches the level specified
- the target pricing contract can be used with product already delivered or with product yet to be delivered
- the target pricing contract contains an expiry date upon which the order will end if the target price has not been hit – an order that has not yet been filled can usually be canceled with 24 hours notice to the buyer, should the seller decide to do so
- a target pricing contract can be particularly useful when farmers are too busy with production activities to follow the markets closely

Contract Tips

Read the contract before signing it. This may mean getting an unsigned copy from the buyer, taking it home and taking the time to study it. Remember, contract contents can be amended by mutual agreement, and a section in disagreement can be omitted or amended to suit both parties. Answering the following can help you get the best contract arrangement:

- Are all charges accounted for?
- Is the quoted price a net price at the delivery point, or will there be additional freight charges?
- Is a grade or specification stated? Are other grades deliverable and, if so, at what premium or discount?
- How is dockage assessed? Is freight to be paid on dockage? Will dockage be paid for and at what price? How are grade and dockage disputes settled?
- Is a delivery date specified? What happens when one party defaults on delivery date? Will the buyer pay storage charges after a certain date? Will the buyer pay post-delivery interest charges after a certain date?
- What protection does the seller have in case of payment default by the buyer?

Feed Pea Futures Contracts

- Specifications

- Pricing Basis	Free on Board points in the Par region
- Delivery Months	February, April, June, August, October, December
- Currency	Canadian Dollars
- Deliverable Specifications	any grade, color, or variety of field pea (including whole, split, chipped and broken field pea) with maximum 16% moisture, maximum 1% heated seed and maximum 8% foreign material including no more than 0.01% excreta and 0.05% ergot
- Par Delivery Region	locations within the provinces of Manitoba, Saskatchewan and Alberta (excluding the Peace River District)
- Contract Size	1 contract = 20 tonnes 5 contracts = 1 board lot
- Trading Hours	9:30 a.m. to 1:15 p.m. CT
- First Notice Day	one business day prior to the first delivery day
- First Delivery Day	last business day of the delivery month
- Minimum Price Fluctuation	$0.10/tonne
- Daily Limit	$5.00/tonne above or below previous settlement

- Par Delivery region represents any area in Manitoba, Saskatchewan and Alberta (excluding Peace River District). The trade appointed elevators are deliverable points.
- The objective of the contract is that the futures price reflects the lowest price on the prairies at all times.
- Due to seasonal factors, relative prices throughout the year can change and so will the delivery point.
- For the most part, there is an $8 to $10/t spread between regions at any given time, with central Saskatchewan areas generally offering the lowest price.
- Prices in the Peace area are more inconsistent with the rest of the prairies, so the region is excluded.
- Payment is made on 4 per cent dockage but delivery can be up to 8 per cent.
- Basis relationships can change throughout the year. When Thunder Bay is actively shipping in November, the delivery point will move further west, as it represents a lower price. If Vancouver is loading in February when Thunder Bay is closed, the delivery point would move further east.
- Calculating basis - *example* - assume the futures price is $150/t.
  - minus $10 to $13/t - elevation
  - minus $2/t - administration
  - minus $0 to $3/t - carry (storage and interest)
  - minus $0 to $3/t - opportunity cost
  - plus $6/t - net/gross adjustment; get paid on 4% dockage
  - locational adjustment -10 to +10
  - basis will range 10 to 15 under
    - this will change with locational adjustment
  - the futures price reflects the lowest price on the prairies, which will keep changing. There will be premiums and discounts associated with the basis at different times of the year.

Not all above credits/debits would be included at all times or by all companies. Numbers and ranges will vary company to company and under various market circumstances.

Feed Pea Basis Calculation

The feed pea futures market allows Canadian farmers to follow prices in Europe, the major user of feed pea.

Basis is the difference between a futures price and local Canadian cash price. Because of the European delivery point and U.S. currency of the feed pea futures market, the feed pea basis contains more factors than other grains.

Example spot market basis calculation:

April 23, 1998, closing price for May feed pea futures
$143/tonne U.S.

Conversion to Canadian currency @ .6966 spot exchange rate
$205.28/tonne Cdn.

Compared to April 23, 1998, local elevator price: $3.35/bu. X 36.75 bu./t.
$123.10/tonne Cdn.

April 23, 1998 basis level (delivered to that particular buyer)
$ 82.18/tonne Cdn.

Knowing historic basis ranges and the factors involved in the pea basis is necessary to assess the relative strength of a current basis level. In Alberta, the spot market basis level for elevator-delivered feed pea has had a two-year range of $60/t Cdn. to $130/t. Cdn.

Here is a simplified example of the European-based futures price worked back to Alberta:

May pea futures
$143/tonne U.S.

MINUS ocean freight (Vancouver range $22-$35 U.S.)
$28/tonne U.S.
(Thunder Bay about $10/t more than Vancouver)

EQUALS feed pea price F.O.B. Vancouver Port
$115/tonne U.S.

Conversion to Canadian currency @ .6966 spot exchange rate
$165/tonne Cdn.

MINUS Fobbing (cost to load ship), Canadian port
$10/tonne Cdn.

EQUALS feed pea price (in-store Vancouver terminal)
$155/tonne Cdn.

MINUS rail freight Central Alberta to Vancouver
$28/tonne Cdn.

MINUS elevator basis
$8/tonne Cdn.

EQUALS **$119/tonne Cdn.**

Using the rates above, this calculation implies that the current local domestic price of $123.10/tonne compares favorably to the futures-derived price of $119/tonne. Either the elevator company offering $123.10/tonne is taking less than $8/tonne for elevation, or other resale opportunities (e.g. Canadian domestic demand) are producing a price greater than the option of exporting feed pea to Europe at this time.

Electronic Marketing

There are four electronic markets available in Alberta, all available through the Internet:

A.J. Bat (http://www.canadagrain.com)

- **A.J. Bat (Allan Johnston Bid-Ask-Trade)** is a site where buyers and sellers can list what they want to buy and sell
  - lot size, terms of sale and price are listed
  - there is no charge for buyers or sellers to post a bid or ask
  - if there is a grading problem, then the Canadian Grain Commission is consulted
- **A.J.BATexport Trading Page** is where producers, processors and buyers (both locally and internationally) post product for sale or product wanted
  - all prices are converted to a common point of export depending on the crop
  - individual companies and processors then work back the price to their point of origin

Ag-Direct.Com (http://www.ag-direct.com)

- **Ag-Direct.Com** is an electronic marketplace for feed grains where customers can trade in specific regions across Western Canada
  - it has approval of the Alberta, Saskatchewan and Manitoba Securities Commissions to operate as an Exchange
  - it allows trading in the spot, forward and basis markets
  - the system was designed by grain traders for grain traders
  - all potential users are closely screened
  - AgraLink handles all payments and has an optional freight exchange service for trucking

CBH Commodities (http://www.cbhcommoditiesonline.com)

- offers a service where producers can list crop information that can be sent to multiple buyers

Market Master Ltd. (http://www.grainwatchdog.com)

- feed barley, wheat, pea, canola, oats, rye, flax and triticale are marketed to the feed industry in Alberta, B.C. and the U.S.

Green Pea Production

How to make certain your green pea crop makes the grade

The lowest grade for human edible green pea, Canada No. 2, requires a sample with no more than 1 per cent other classes (off-types or admixtures), 3 per cent or less bleached seed and 5 per cent or less total damage, with minimum earth tag.


Green pea sample-desicated

Other quality factors or standards are also used in the grade table, but off-types, bleach and earth tag are the three most important factors that can downgrade green pea samples to feed.


Green pea natural drydown

Following these next tips can help producers achieve the all-important Canada No. 1 or 2 grade for the premium, human edible green pea market.

Off-types and Admixtures

- don't use seed that contains admixtures of yellow or maple pea (pea characterized by a dark brown seed coat) – maple pea (distinguished by its purple-colored flower) can be rogued in the field
- if you're growing both yellow and green pea on your farm, eliminate contamination at seeding and harvest
  - keep machinery clean
  - clean augers before moving from one type/color of pea to another
  - use belt conveyors, rather than conventional augers, if possible

Minimize Bleach

Green pea bleaching occurs when harvest is delayed, and maturing seed is exposed, over time, to wet and drying conditions as well as sunlight. Bleach is defined as the discoloration of more than 1/8 of the pea seed cotyledon.

If more than three pea seeds in 100 have a bleached area (that is, a white or yellow color larger than 1/8 of the seed), the sample will grade less than Canada No. 2. The longer the crop stays out, the greater the likelihood of bleaching. In other words, every day in the field costs you money.

Here's how you can minimize bleach:

- select uniform fields and seed early
- seed green pea **FIRST**
- control perennial weeds the year before with a pre-harvest application of Touchdown® or Roundup®
- scout fields before harvest to determine when the crop is ready for harvest
- use Reglone PRO® desiccant with high water volumes when most of the field is ready for desiccation
- green pea will be ready for harvest five to seven days after desiccation – ensure maximum combine capacity for rapid harvest, and use a second combine if available

Earth tag Management

To reduce earth tag in green pea, follow these management tips:

- select a green pea variety with a good harvest rating
- roll your pea field just after seeding, to eliminate ridges and an uneven seed bed, as this approach will minimize dirt entering the combine (normal plant dust will not adhere to a dry pea seed coat, but combined soil will)
- use Reglone PRO® at the proper desiccation stage to even out crop drydown and eliminate green weed material – green material (either green weeds or green pea plant material) will increase the level of earth tag on the seed
- combine when seed moisture content reaches 18 to 20 per cent for the first time – properly tuned aeration bins are essential for a green pea harvest
- field pea combined at 18 to 20 per cent moisture will require aeration conditioning for short-term storage

See also Table 21 Grades of Green Pea in this section.

Green Pea Bleach Study Results

A three-year project, involving nine green pea varieties at a site north of Edmonton, was conducted to study different desiccation practices and their effects on green color retention of the seed. The study concluded that quality green pea crops can be produced profitably in Alberta.

- all nine green pea cultivars graded Canada No. 2 or better when desiccated with Reglone PRO® at the correct time and with high water volumes (combining occurred six to seven days after desiccation in all three years)
- green pea varieties vary in their susceptibility to bleaching, with smaller seeded varieties being slightly less susceptible (in this study, seed size differences did not affect final grade)
- one treatment in the study – which included natural drydown, no desiccation and late harvest – resulted in all varieties being downgraded to a Canada No. 3 or feed quality
- natural drydown resulted in pea harvest occurring about two weeks later than the desiccated plots
- natural drydown produced seed with more bleach as well as an increased number of pea seeds with a dull, less intense green color

Varieties For Alberta

Table 24 and Table 25 show field pea data from the Alberta Field Pea Regional Variety Test Program. The format used for the tables is similar to **Agdex 140/32-1, *Varieties of Special Crops in Alberta***.

The data and descriptions represent varieties currently being tested. Separate descriptions for varieties previously tested, with sufficient data, are also listed as "fully tested varieties." When pedigreed seed of the older varieties becomes unavailable in Alberta, the variety will be removed.

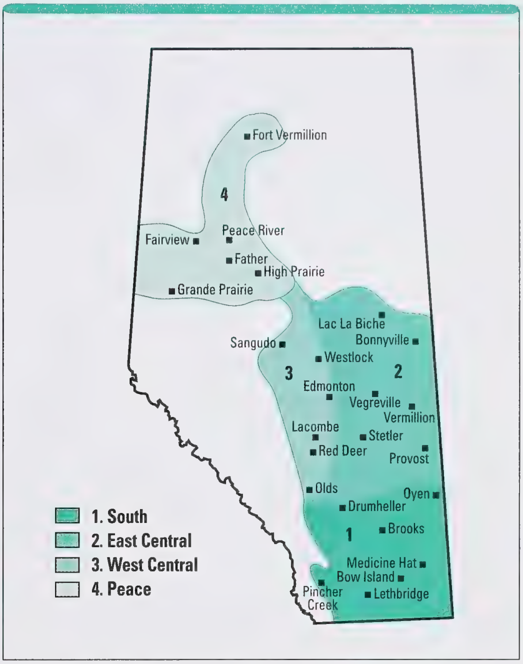
Variety Testing Procedures

Compilation and coordination of the Field Pea Regional Variety Test is the responsibility of the Special Crops Program of Alberta Agriculture's Crop Diversification Centre South under the sponsorship of the Special Crops Variety (ad hoc) Committee, with funding support from the Alberta Pulse Growers Commission and participating seed companies.

Choosing a Pea Variety

The variety of field pea you choose should depend on your market (feed or edible, green, yellow or maple).

With more varieties now available, it's harder to choose the best variety for a particular site and year. The most important criteria of the selection process is YIELD. A number of site-years provides the best data only if these sites represent similar growing conditions. Check data from local zone, industry and regional trials. For test data and other particulars, consult with personnel involved with testing and handling seed.



Alberta pea testing regions

The following checklist of variety factors should help in variety selection:

- **location**: use a combination of growing season precipitation and soil type – data from sites with abnormal precipitation the previous year may be suspect
- **vine length**: longer vine varieties (80 cm or longer) usually perform better in drier areas; shorter varieties (70 cm or shorter) do better in areas with higher moisture or with high soil nitrogen levels (shorter varieties, on average, mature earlier and perform better in short season areas)
- **standability**: this rating considers vine length, amount of precipitation, wind damage, variety and soil nitrogen levels – all standability ratings are lower in dry years compared to wet years, even for the same variety (if standability is important, choose varieties with ratings of 5.0 or less)
- **maturity**: influenced by variety, precipitation, temperature and vine length – higher rainfall and short growing season areas require shorter vine, earlier maturing varieties

Table 24. Green field pea variety summary

Relative Yield (% of check) 1994-1998							Agronomic Characteristics			
Regions (see map)							Average of all Regions 1994-1998			
Green Varieties	Irr. 1	1	2	3	4	Yield (% of check) all regions	Maturity (+/- check)	Vine length (cm)	Seed wt. (g/1000)	Standability 1E-9F **
Adagio (a)	101	93	102	98	97	98	1.0	72	231	6.2
Astina (a)	98	104	100	89	100	98	0.8	72	233	4.9
Astuce (a)	89	88	83	84	86	86	-0.1	64	243	5.7
CDC Peko	81	71	79	72	79	77	3.6	70	177	7.9
Columba (a)	109	88	97	95	100	97	1.6	80	258	5.3
Carneval*	**100**	**100**	**100**	**100**	**100**	**100**	**0.0**	**79**	**223**	**3.6**
CPB Phantom	109	106	100	103	96	101	-0.4	61	284	5.5
DP 138694 (a)	112	116	96	106	96	104	-2.4	65	258	4.9
Espace (a)	111	113	97	110	106	107	-1.3	70	217	4.5
Explorer	91	96	98	86	97	94	0.0	78	225	5.7
Pekisko (a)	124	101	81	92	85	93	-4.2	69	177	4.9
Scuba (a)	108	97	89	93	86	93	-2.0	72	208	4.8

*__Carneval-check variety__. Average yield all Regions 4517 kg/ha., 96 days to mature.
**Standability rating 1=Erect, 9=Flat. Varieties marked (a) are first-year entries in 1998.

- **seed size**: influences both seeding rate and seeding cost – in some cases, larger seed varieties produce higher yield, but the cost of seed should be considered in light of any potential yield increase (market type – including seed size, shape and cotyledon color – is also important)
- **leaf type**: most field pea varieties are semi-leafless, while others are normal leaf types –normal leaf types usually perform better in dry areas, while semi-leafless types perform best in higher moisture areas

Field Pea – Green Variety Descriptions

Adagio

- medium size green cotyledon pea with a 231 gm/1000 seed weight
- this semi-leafless pea yields similar to Carneval
- vine length is 72 cm – shorter than Carneval but longer than Keoma
- matures 1 day later than Carneval
- *Company contact*: Performance Seeds

Astina

- medium size green pea with a 233 gm/1000 seed weight
- yields similar to Carneval
- this semi-leafless pea is 7 cm shorter than Carneval with similar maturity
- *Company contact*: CanSeed Canada

Astuce

- a medium size semi-leafless green pea with a 243 gm/1000 seed weight
- yields about 14 per cent less than Carneval
- similar in maturity to Carneval but with a short vine length of 64 cm
- *Company contact*: Brett-Young Seeds

Columba

- a semi-leafless, medium size pea, 258 gm/1000 seed weight
- yields 3 per cent less than Carneval
- has a better standability rating than Keoma and a vine

length similar to Carneval
- *Company contact*: Performance Seeds

DP138694

- a semi-leafless green field pea line with a 258 gm/1000 seed weight
- vine length slightly less than Carneval, but a poorer lodging rating
- DP138694 out-yielded Carneval by 4 per cent
- *Company contact*: Pickseed Canada

Espace

- this semi-leafless green pea has a seed size of 217 gm/1000 seeds and is not perfectly round and smooth
- yields 7 per cent better than Carneval
- standability rating slightly below Carneval
- *Company contact*: St. Denis Seeds

Explorer

- semi-leafless, green cotyledon pea with a medium vine length (78 cm)
- Explorer yields 6 per cent less than the check variety Carneval and is similar in maturity
- Explorer has a medium-small seed size, 225 gm/1000 seed weight
- *Company contact*: Newfield Seeds

Pekisko

- a small-seeded green pea similar to Radley, 1000 seed weight of 177 gm
- this semi-leafless variety yields 7 per cent less than Carneval
- *Company contact*: Agricore

CDC Peko

- normal leafed, green cotyledon pea with a medium long vine length (70 cm)
- CDC Peko has yielded 23 per cent less than the check variety Carneval and is 3.6 days later to mature
- Peko has a small seed size, 177 gm/1000 seed weight
- *Company contact*: SeCan

CPB Phantom

- semi-leafless, green cotyledon pea with a short vine length (61 cm)
- Phantom yields 1 per cent more than the check variety Carneval and is 0.4 day earlier to mature
- Phantom has a large seed size, 284 gm/1000 seed weight
- *Company contact*: SeCan

Scuba

- is a small green pea with a 1000 seed weight of 208 grams
- this semi- leafless cultivar matures 2 days earlier than Carneval and yields 7 per cent less
- intended as a replacement for Radley, but the bleach potential of Scuba is poorer than Keoma
- *Company contact*: Performance Seeds

Field Pea – Yellow Variety Descriptions

Alfetta

- a semi-leafless, yellow cotyledon pea with a short vine length (66 cm)
- Alfetta yields 5 per cent more than the check variety Carneval and is 2.1 days earlier to mature
- large seed size, 272 gm/1000 seed weight
- *Company contact*: Performance Seeds

Baccara

- a large yellow cotyledon pea with a 273 gm/1000 seed weight
- out-yields Carneval by 8 per cent
- this semi-leafless pea is 61 cm in vine length and matures about two days earlier than Carneval
- *Company contact*: St. Denis Seeds

SW Bravo

- a medium yellow cotyledon pea with a 231 gm/1000 seed weight
- yields similar to Carneval and two days earlier in maturity
- this semi-leafless cultivar has similar standability to Carneval
- *Company contact*: Agricore

Bridge

- a medium-large yellow cotyledon pea that has yielded 8 per cent better than Carneval
- similar maturity as Carneval with a 65 cm vine length
- this semi-leafless yellow pea has a 263 gm/1000 seed weight
- *Company contact*: St. Denis Seeds

Table 25. Yellow field pea

Yellow Varieties	Irr. 1	1	2	3	4	Yield (% of check) all regions	Maturity (+/- check)	Vine length (cm)	Seed wt. (g/1000)	Standability 1E-9F **
	Relative Yield (% of check) 1994-1998						Agronomic Characteristics			
	Regions (see map)						Average of all Regions 1994-1998			
Alfetta	112	113	98	108	101	105	-2.1	66	272	4.8
Baccara (a)	122	108	111	105	102	108	-1.6	61	273	5.2
SW Bravo (a)	111	98	97	103	101	101	-1.9	75	231	3.9
Bridge (a)	102	104	112	105	112	108	-0.2	65	263	5.9
Canis	92	100	96	98	104	99	0.4	80	230	4.1
Carneval*	**100**	**100**	**100**	**100**	**100**	**100**	**0.0**	**79**	**223**	**3.6**
Carrera	107	112	102	109	96	104	-1.1	65	254	5.5
Ceb 1441 (a)	122	103	80	98	90	96	-1.3	59	277	4.3
Cobra (a)	115	104	99	97	98	101	-1.0	74	222	5.2
Cresta (a)	124	107	93	92	97	101	-1.8	58	254	5.3
Croma (a)	109	105	97	109	98	102	-0.7	60	289	4.7
Delta (a)	120	117	105	103	108	109	-1.0	70	227	5.1
Eiffel	109	116	107	105	103	107	-1.3	78	273	4.1
Integra (a)	111	105	94	103	88	98	-3.1	78	251	4.0
Loto (a)	128	108	91	107	99	104	-1.6	60	284	5.9
AC Melfort (a)	122	103	96	97	110	105	1.4	61	217	5.7
Miami (a)	110	109	101	107	108	107	-1.4	76	219	4.0
Nicole (a)	133	110	91	107	105	107	-2.0	58	256	4.7
Swing (a)	110	107	94	108	92	100	-2.8	73	227	4.7

***Carneval-check variety**. Average yield all Regions 4517 kg/ha., 96 days to mature.
**Standability rating 1=Erect, 9=Flat. Varieties marked (a) are first-year entries in 1998.

Canis

- semi-leafless, yellow cotyledon pea with a long vine length (80 cm)
- Canis yields 1 per cent less than the check variety Carneval and is .4 days earlier to mature
- medium seed size, 230 gm/1000 seed weight
- *Company contact*: Newfield Seeds

Carneval (check variety)

- semi-leafless, yellow cotyledon pea with a long vine length (79 cm)
- mean yield during this testing period is 4517 kg/ha and maturity is 96 days
- Carneval has a medium-small seed size, 223 gm/1000 seed weight
- *Company contact*: Agricore

Carrera

- semi-leafless, yellow cotyledon pea with a short vine length (65 cm)
- Carrera yields 4 per cent more than the check variety Carneval and is 1 day earlier to mature
- medium seed size, 254 gm/1000 seed weight
- *Company contact*: CanSeed Canada

Ceb 1441

- a large yellow cotyledon pea that yields 4 per cent less than Carneval, a short vine length (59 cm) and seed size of 227 gm/1000 seed weight
- one day earlier to mature than Carneval
- *Company contact*: Cebeco Zaden B.V.

Cresta

- this yellow pea has a seed weight of 254 gm/1000 seeds
- similar yield to Carneval
- vine length is 58cm
- *Company contact*: Sharpes International

Cobra

- a yellow cotyledon pea with a 222 gm/1000 seed weight
- slightly shorter than Carneval, and matures 1 day earlier than Carnavel
- has yield similar to Carneval
- *Company contact*: Canterra Seeds

Croma

- a large yellow cotyledon pea with a 289 gm/1000 seed weight
- yielded 12 per cent better than the check variety Carneval
- *Company contact*: Canterra Seeds

Delta

- a medium-small size, 227 gm/1000 seed weight, yellow cotyledon pea with a 9 per cent higher yield and earlier maturity compared to the check Carneval
- this semi-leafless variety is 1 day earlier to mature than Carneval and is poorer in standability compared to Carneval
- *Company contact*: Performance Seeds

Eiffel

- semi-leafless, yellow cotyledon pea with a medium-long vine length (78 cm)
- Eiffel yields 7 per cent more than the check variety Carneval and is 1.3 days earlier to mature
- Eiffel has a large seed size, 273 gm/1000 seed weight
- *Company contact*: Limagrain Canada

Integra

- large yellow cotyledon pea with yield and standability similar to Carneval
- yields 2 per cent less than Carneval
- this semi-leafless pea matures 3 days earlier than Carneval and is similar in vine length
- *Company contact*: St. Denis Seeds

Loto

- a large yellow cotyledon pea that yields 4 per cent higher than Carneval
- matures 1.6 days earlier than Carneval
- semi-leafless yellow pea has 284 gm/1000 seed weight
- *Company contact*: St. Denis Seeds

Miami

- a medium-small size yellow pea with a seed weight of 219 gm/1000 seeds
- this variety yielded 7 per cent higher than Carneval
- maturity is 1.4 day earlier than Carneval
- *Company contact*: Advanta Seeds

AC Melfort

- a medium-small yellow cotyledon pea with a 217 gm/1000 seed weight
- yields 5 per cent better than Carneval
- the first pea cultivar registered in Canada with powdery mildew resistance
- this semi-leafless variety has poorer standability than Carneval and a shorter vine length (61cm)
- *Company contact*: Cantarra Seeds

Nicole

- medium size yellow pea has a seed weight of 256 gm/1000 seeds
- Nicole out-yielded Carneval by 7 per cent
- maturity is two days earlier than Carneval, with a short vine length (58cm)
- *Company contact*: Advanta Seeds

Swing

- a medium-small size yellow pea with a 227 gm/1000 seed weight
- yields similar to Carneval
- this semi-leafless variety is 2.8 days earlier to mature than Carneval and 6 cm shorter
- *Company contact*: CanSeed Canada

Fully Tested Yellow Varieties

Baroness

- semi-leafless, yellow cotyledon pea with a long vine length (80 cm)
- Baroness has 79 station-years in the Alberta Regional Pea Variety Test Program
- Baroness yields 1 per cent more than the check variety Carneval and is 1.9 days later to mature
- has a large seed size, 282 gm/1000 seed weight
- *Company contact*: Performance Seeds

Discovery

- normal leafed, yellow cotyledon pea with a medium long vine length (74 cm)
- has 49 station-years in the Alberta Regional Pea Variety Test Program
- Discovery yields 2 per cent more than the check variety Carneval and is 2.1 days later to mature
- Discovery has a very large seed size, 301 gm/1000 seed weight
- *Company contact*: Newfield Seeds

Grande

- normal leafed, yellow cotyledon pea with a long vine length (84 cm)
- Grande has 71 station-years in the Alberta Regional Pea Variety Test Program
- yields 8 per cent more than the check variety Carneval and is 2.4 days later to mature
- medium seed size, 244 gm/1000 seed weight
- *Company contact*: Newfield Seeds

Highlight

- semi-leafless, yellow cotyledon pea with a medium long vine length (72 cm)
- has 60 station-years in the Alberta Regional Pea variety Test Program
- Highlight yields the same as the check variety Carneval and is 0.7 day earlier to mature
- a small seed size of 201 gm/1000 seeds
- *Company contact*: Newfield Seeds

Montana

- semi-leafless, yellow cotyledon pea with a short vine length (62 cm)
- has 77 station-years in the Alberta Regional Pea Variety Test Program
- Montana yields the same as the check variety Carneval and is 2.4 days earlier to mature
- large seed size, 275 gm/1000 seed weight
- *Company contact*: CanSeed Canada

Profi

- a semi-leafless, yellow cotyledon pea with a long vine length (82 cm)
- Profi has 49 station years in the Alberta Regional Pea Test Program
- Profi yields 2 per cent more than the check variety Carneval and is three days earlier to mature
- a medium seed size, 258 gm/1000 seed weight
- *Company contact*: SeCan

Scorpio

- normal leafed, yellow cotyledon pea with a short vine length (59 cm)
- has 59 station-years in the Alberta Regional Pea Variety Test Program
- Scorpio yields 5 per cent less than the check variety Carneval and is three days earlier to mature
- medium-large seed size of 263 gm/1000 seeds
- *Company contact*: Brett-Young Seeds

Fully Tested Green Varieties

Ascona

- a semi-leafless, green cotyledon pea with a short vine length (63 cm)
- has 49 station-years in the Alberta Regional Pea Variety Test Program
- Ascona yields 2 per cent less than the check variety Carneval and is 0.5 day earlier to mature
- large seed size of 277 gm/1000 seeds
- *Company contact*: St. Denis Seeds

Danto

- semi-leafless, green cotyledon pea with a short vine length (63 cm)

- has 60 station-years in the Alberta Regional Pea Variety Test Program
- Danto yields 5 per cent less than the check variety Carneval and is 1.6 days later to mature
- has a large seed size of 272 gm/1000 seeds
- *Company contact*: Brett-Young Seeds

Keoma

- semi-leafless, green cotyledon pea with a short vine length of 66 cm
- has 89 station-years in the Alberta Regional Pea Variety Test Program
- yields 5 per cent less than the check variety Carneval and is 1.3 days later to mature
- a medium-small seed size of 215 gm/1000 seeds
- *Company contact*: Agricore

Majoret

- a semi-leafless, green cotyledon pea with a medium long vine length (77 cm)
- has 71 station-years in the Alberta Regional Pea Variety Test Program
- Majoret yields 3 per cent less than the check variety Carneval and is 0.8 day earlier to mature
- medium seed size of 254 gm/1000 seeds
- *Company contact*: Newfield Seeds

Radley

- semi-leafless, green cotyledon pea with a medium long vine length (72 cm)
- has 52 station-years in the Alberta Regional Pea Variety Test Program
- yielded 9 per cent less than the check variety Carneval and is 0.7 day later to mature
- has a small seed size of 198 gm/1000 seeds
- *Company contact*: Columbia Seeds

Totem

- a semi-leafless, green cotyledon pea with a short vine length of 63 cm
- has 49 station-years in the Alberta Regional Pea Variety Test Program
- Totem yields 5 per cent less than the check variety Carneval and is 1.4 days earlier to mature
- a medium seed size of 234 gm/1000 seeds
- *Company contact*: Newfield Seeds

Inoculation of Field Pea

Properly peat inoculated pea seed

3 to 5 week old plant with beginning nodulatioin

Inoculating pea with the correct strain of *rhizobia* will help meet the nitrogen requirements of the pea crop. Properly inoculated pea should not require any extra nitrogen fertilizer.

Nodules will begin to appear on pea roots three to five weeks after seeding. When nodules are visibly red or pink when cut in half, the *rhizobia* are fixing nitrogen. If no nodules have appeared after this time, inoculation was unsuccessful and a broadcast application of nitrogen fertilizer may be considered.

Nodules on field pea roots will begin to die and turn greenish-brown to brown as the plants reach the late flowering to early pod filling stage.

Peat applied inoculant (nodules at the crown)

Granular applied inoculant (more nodules on lateral roots)

Inoculant Formulation

Inoculant is available in three different formulations for use with field pea:

- peat powdered (including self stick peat)
- liquid
- granular

Much research has been done on different formulations of inoculants for use with pea. Table 26 shows how field pea responds, with different formulations of inoculant at sites where there is a response to inoculation.

Table 26. Response of field pea to different inoculant formulations

Formulation	Nodulation Rating (0-8)	Yield (bu./acre)	Protein (%)	Nitrogen Fixation (kgN/acre)
Granular	5.8	71	18.5	100
Peat Powder	5.6	65	17.4	76
Liquid	4.0	57	17.1	53
Uninoculated	4.0	55	16.9	53
Significance	sig	sig	sig	sig

Rice and Clayton 1998.
Based on 13 responsive sites in Alberta.

This is what the research indicated:

- the use of **granular** inoculant resulted in the highest pea yields, in cases where a statistically significant response to inoculation was evident
- under cold or very dry spring seedbed conditions, **granular soil inoculation** has shown considerable potential for producing large, stable yields of field pea and minimizing the risk of growing the crop
- **liquid inoculant** produced significant differences at some sites – when averaged over a number of sites, however, liquid inoculant showed a limited response
- some sites show little to no response to inoculation with any formulation as these sites had previous pea crops or naturally occurring (native) *rhizobia*
- when seeding on land with no known history of field pea, it's best to use inoculant at recommended rates – although some *rhizobia* occur naturally in soils, it's important to ensure sufficient numbers of the **correct** strain of highly effective *rhizobia* are present when the seed germinates

Seed Quality

Germination and Vigor

Germination testing is one method for evaluating seed lots for quality. Germination addresses the seed's ability to develop into a normal, healthy plant under favorable field conditions. However, this testing can be misleading because seed may germinate well in the lab due to optimum conditions being present or to the fact that the seed has every opportunity to develop into a normal healthy seedling.

Vigor testing, another method, assesses the seed's potential to withstand unfavorable field conditions by assessing certain factors that influence seed quality. While vigor results represent the lowest germination obtained from the lot, germination testing represents the highest result. Actual field germination would normally fall between the two.

Germination and vigor are influenced by the physiological well-being and anatomical completeness of the seed plus its interaction with a wide range of environmental conditions. Seed vigor is affected by:

- genetic constitution
- seed size and weight
- mechanical integrity and soundness
- deterioration
- aging
- pathogens
- stage of maturity
- climatic conditions

In years where unfavorable weather conditions prevail, it is best to combine a vigor test with a germination test to determine seed quality and performance more accurately. Be sure germination results include adequate categorization of the seedling defects and the seedling's ability to survive adverse conditions.

It's impossible to predict post-seeding conditions with a vigor test, so seed is placed under a variety of stressful conditions, simulating climatic conditions as closely as possible, including:

- cold temperatures
- wet conditions
- micro-organisms
- seed soaking
- accelerated aging

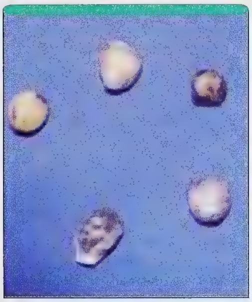
Under these conditions, the seed must demonstrate the ability to germinate into a vigorous seedling.

Pea seedling evaluation characteristics

Normal seedlings – all essential structures present, healthy leaf, strong primary roots with secondary roots.

Mechanical damage – epicotyl and root detached from seed as a result of cracking and splitting.

Pre-Harvest damage – stunted roots with no secondary roots or root hairs.



Dead and diseased seeds – (necrotic tissue) seeds have decayed due to disease and damaged cotyledons.

Evaluating pea vigor

Pea vigor is measured by the Electrical Conductivity Test to assess mechanical damage and evaluate seed lots that remain vigorous during storage. Testing for vigor is an important tool if it is suspected that seed has sustained some injury or that the soil environment will impose stress on the seed. (Research has established a correlation between the Electrical Conductivity Test and actual field results.)

- pea is very susceptible to mechanical injury, such as cracking and chipping, either at harvest or during processing, especially if the moisture level is below 14 per cent
- mechanical injury, such as small seed coat cracks, results in rapid water intake that leads to dead seed cells – this dead tissue then becomes a source of food for invading pathogens
- vigor grades may be used as parameters for sowing times as well as assessing damage:
  - 0-20 µs **high vigor**: little or no mechanical damage – suitable for early sowing
  - 20-30 µs **medium vigor**: some mechanical damage – some seed bed losses may occur in adverse weather conditions but may be used for later drilling in more favorable conditions
  - 30-40 µs **low vigor**: moderate to high mechanical damage – not suitable for early sowing and may fail in cold wet conditions
  - 40 µs **very low vigor**: severe mechanical damage – not suitable for sowing at all
- vigor tests must be combined with germination tests to predict field performance
- the seed may also require 1000 seed weight and disease tests to completely assess the seed's total quality

Fertility Requirements

Introduction

Understanding the fertilizer requirements of field pea is critical to reaching optimum yields. To achieve 50 bushels of pea seed per acre, pea crops (including vines and pods) will require approximately:

- 150 lb. (N) Nitrogen
- 45 lb. (P) phosphate as P_2O_5
- 140 lb. (K) potash as K_2O
- 13 lb. (S) sulphur
- over 100 lb. (Ca) calcium
- 15 lb. (Mg) magnesium

A 100 bushel per acre crop typically needs double the above amount of nutrients.

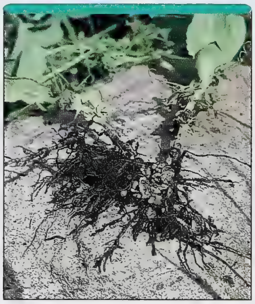
Pea field with optimum fertility

Nitrogen (N)

Field pea has the ability to fix nitrogen from the air. The process works like this:

- pea forms a symbiotic relationship with specific bacteria, which live in association with plant roots
- the bacteria infect the plant roots and form nodules
- the bacteria use nutrients from the plant and provide nitrogen to the plant in return

Properly inoculated pea seed



Nitrogen fixing nodules

For this reason, most of the nitrogen required by pea can be provided from the soil and fixation. This can greatly reduce and often eliminate the need to add N fertilizer. Inoculation with the proper strain of rhizobium bacteria is essential to ensure fixation.

Soil tests are also important in deciding whether or not N fertilizer should be applied:

- generally, if soil tests are above 40 lb. N/ac. in the 0 to 24 inch depth, no additional N fertilizer is required
- in soils testing less than 20 lb. N/ac., a small amount of starter N may be beneficial
- in a cold/wet or hot/dry spring, when nodules are slow to develop, plants may be unable to obtain sufficient N from the soil, resulting in a nitrogen deficiency

Lodged pea crop

With pea and nitrogen, it's possible to have too much of a good thing. Excess N fertilizer will reduce the amount of N fixed by a pea crop, delay crop maturity, increase disease levels and reduce standability.

Mid-season N applications are normally not recommended. An exception would be under conditions of failed inoculation and obvious N deficiency.

Phosphorus (P_2O_5)

Adequate levels of phosphorus are critical for optimum yield and early maturity. Phosphorus deficiency restricts top and root growth, resulting in spindly stems with fewer branches.

Phosphorus moves poorly in soil, so it should be placed near the seed. On the other hand, germination and emergence can be reduced if **too much** phosphate is placed with the seed.

- recent field pea research in Alberta has found that up to 30 lb./ac. seed-placed P_2O_5 has not reduced germination or emergence – in fact, under very good seedbed soil moisture conditions, even higher rates of seed-placed phosphate are safe
- this research has also shown that although phosphorus is a limiting factor in many Alberta soils, build-up of soil phosphorus tends to raise available soil phosphorus levels and phosphorus fertilizer responses are often not dramatic

Table 27. General phosphate fertilizer recommendations for field pea in different soil areas of Alberta, based on the Kelowna P soil test method

	P_2O_5 Recommendations (lb./ac.)		
Soil Test P Level (lb./ac.) 0-6 inches	Brown & Dark Brown Soils	Black & Grey Wooded Soils	Irrigation
0 - 10	40	50	60
10 - 20	35	45	55
20 - 30	30	40	50
30 - 40	25	35	45
40 - 50	20	30	40
50 - 60	20	25	30
60 - 70	20	20	20
70 - 80	20	20	20
> 80	0	0	0

Table 28. General potassium fertilizer recommendations for field pea in different soil areas of Alberta, using an ammonium acetate extraction method

K_2O Recommendations (lb./ac.)			
Soil Test K Level (lb./ac.) 0-6 inches	Brown & Dark Brown Soils	Black & Grey Wooded Soils	Irrigation
0 - 50	110	120	130
50 - 100	90	100	110
100 - 150	50	60	70
150 - 200	40	50	60
200 - 250	30	40	50
250 - 300	20	30	40
> 300	0	0	0

Potassium (K_2O)

Pea crops generally need more potassium than cereal crops and often almost as much potassium as they do nitrogen. Only 20 to 25 per cent of the plant potassium is in the seed, however. The rest is in the leaves and stems and is normally returned to the soil.

Many Alberta soils are medium to high in exchangeable potassium, often ranging from 400 to 1000 lb. of potassium/ac. in the 0 to 6 inch depth of soil. Potassium deficiencies are most likely to occur on sandy soils that are intensively cropped or on Grey-Black transition soils and Grey Wooded soils.

- potassium fertilizer is not required when soil tests show greater than 300 lb. potassium/ac.
- banding or seed-placing potassium are the most efficient methods of application
- because large amounts of seed-placed potassium with pea crops may reduce germination and emergence, it may be best to either band it before seeding or sideband it at the time of seeding (this is especially true if phosphorus and sulphur fertilizers are also being applied)

Sulphur (S)

Pea crops have a reasonably high sulphur requirement. Much of the topsoil sulphur is contained in soil organic matter. This is slowly released as sulphate-sulphur (SO_4-S), the form of sulphur that plants require. Sulphate-sulphur is similar to nitrate-nitrogen in that both are mobile in soil.

Some soils are deficient in plant-available sulphur in the topsoil but have enough sulphur in the subsoil to meet crop requirements.

- in wetter, cooler conditions, plants may suffer from a lack of sulphur before plant roots grow down into the subsoil containing sulphur
- sulphur deficiencies are frequently a problem in the Black and Grey Wooded soil areas of Alberta and occasionally a problem in the Brown and Dark Brown soil areas
- for testing purposes, soil samples should be taken from the 0 to 6, 6 to 12 and 12 to 24 inch depths to determine the amounts of sulphur at each depth
- if sulphur is required, apply a sulphate containing fertilizer such as ammonium sulphate (21-0-0-24)
- elemental sulphur fertilizer won't be available to the plant in the year it is applied – elemental sulphur is best used in a longer term program to build soil sulphur levels
- use Table 29 as a guide for rate requirements if soil sulphur levels are less than 20 lb./ac.

Table 29. General sulphate-sulphur fertilizer recommendations for field pea in different soil areas of Alberta

Sulphate-Sulphur Recommendations (lb./ac.)			
Soil Test S Level (lb./ac.) 0-12 inches	Brown & Dark Brown Soils	Black & Grey Wooded Soils	Irrigation
0 - 5	20	25	25
5 - 10	15	20	20
10 - 15	10	15	15
15 - 20	5	10	10
> 20	0	0	0

Micronutrients for Field Pea

Producers can build up micronutrient fertility levels that are low or deficient in much the same way that the better producers build up and maintain adequate sulphur levels for canola production.

To achieve a 50-bushel yield of pea, the micronutrients needed are:

- 0.06 lb. (B) boron
- 0.09 lb. (Cu) copper

- 0.63 lb. (Fe) iron
- 0.45 lb. (Mn) manganese
- 0.09 lb. (Zn) zinc
- trace amounts of (Mo) molybdenum
- field pea can tolerate what is considered low or deficient Cu, Zn or B levels, but note that pea is not grown continuously on the same land – other rotation crops such as flax, wheat, canola and barley may respond optimally to the topped up levels of these minerals
- the three remaining micro-nutrients – iron, manganese and molybdenum – have a much more critical effect
- most Alberta soils are adequate for iron but high pH soils or alkaline soils may lock up manganese availability so that a foliar application of this micronutrient may be necessary
- on the other hand, molybdenum becomes much less available in acidic soils (below pH 6.5) especially at pH 5.5 or less
- molybdenum is absolutely essential in the nitrogen fixation process in legumes – without it, no nitrogen can be fixed (in Europe, producers may apply 200 to 300 grams of actual molybdenum to the seed crop or soil every few years or lime the soil to bring up the pH and release more molybdenum)
- based on soil test results, micro-nutrient fertilizer should be applied in test strips the first year. Sandy, low organic matter may show best response

For more information, recommended soil micronutrient levels are tabulated in the fact sheet: Minerals for Plants, Animals and Man, Agdex 531-3 and Micronutrient Requirements of Crops, Agdex 531-1.

Seeding Management

Site Selection

Site selection is key when planning for field pea in the rotation. In fact, planning for field pea production should begin a year prior to planting. Here are some recommendations for selecting suitable fields.

- fields chosen for pea production should be thistle-free, since no herbicides are registered for complete thistle control in field pea (see ***Herbicides for Use in Pea*, Agdex 142/642-4**)
- use fall tillage or a pre-harvest glyphosate product in the crop before pea to control thistles
- keep good records on herbicides used in previous crops – some leave residues that will injure the pea crop (refer to ***Weed Control in Pea-Preparing for Your Pea Crop*, Agdex 142/642-1**, and always read the herbicide label and pay close attention to re-cropping restrictions)
- do not seed field pea on summerfallow, on heavily manured fields or on fields that received nitrogen the previous fall – high nitrogen levels cause excessive growth, which leads to lodging, disease and nitrogen fixation problems
- avoid rocky fields – harvest operations for field pea are usually done close to the soil surface, and rocks can damage a combine
- poorly drained fields should be avoided to reduce the incidence of seed and seedling diseases


Clean uniform stand


Herbicide residue injury

Seeding Rates

Seeding rates of 75 to 90 plants per square meter (7 to 9 plants per square foot) are recommended in Alberta.

Field pea seed varies in size depending on variety and the climate in which it is grown. To get the proper seeding rate, use the following seeding rate calculation. It takes into account the size of the seed, germination

Inadequate plant population (5 plants per sq. ft.)

rate and an assumed mortality of the germinating seed. Calculate the weight of 1000 seeds in grams. This results **in a 1000 kernel weight (kwt)**.

Seeding Rate Calculation:
(to achieve 7 viable plants per square foot)

$$\frac{\textbf{7 plants/ft.}_2 \textbf{ x 1000 kwt} \div \textbf{10}}{\textbf{viability} \text{ (germination-small \% for seedling mortality)}}$$

Example:

Target is 7 plants/ft.$_2$, seed weight is 230 grams/1000 seeds, germination is 93 per cent, and assumed mortality of seedlings is 3 per cent

$$\frac{\textbf{7 plants/ft.}_2 \textbf{ x 230} \div \textbf{10}}{\textbf{(0.93 - 0.03)}} \textbf{ = 186 lb./ac. seeding rate}$$

Seed Drill Calibration: (based on 15 cm row space)

$$\frac{\textbf{Seeding rate}}{\textbf{2}} \textbf{ = seed wt. (gm) per 100 ft. of row}$$

Example:

186 lb./ac. ÷ 2 = 93 gm of seed per 100 ft. of row per seed cup
For 17.5 or 20 cm row spacing, simply multiply the 15 cm rate by 17.5/15 (1.17) or 20/15 (1.33)

Seeding

- field pea should be seeded before May 15, to maximize quality and yield – this ensures maximum flower development before late July's hot weather, which decreases yield
- early-seeded field pea should be ready for harvest by the third or fourth week of August, before other crops – a September harvest means cooler, damper nights, which result in slower vine drying (high-moisture vines cause threshing problems)
- seed field pea when average soil temperatures are 4-5° C or higher at depth of seeding
- young pea seedlings can tolerate moderate frost
- treat seed with a recommended fungicide when seeding into cold/wet soil
- seed healthy, high-germinating seed with strong vigor to ensure a strong, even emergence and stand (this start should make harvest easier)
- seed field pea to moisture at a depth of 5 cm to 9 cm
- air seeders or hoe drills work well, disc drills less well – disc drills do not seed to uniform depths in undulating fields or in fields with a heavy trash cover
- adjust air seeder air speeds to prevent seed damage
- conventional drills must have large enough seed cups and adequate metering devices for large seed delivery
- maintain constant ground speed for even seed distribution

Direct Seeding of Field Pea

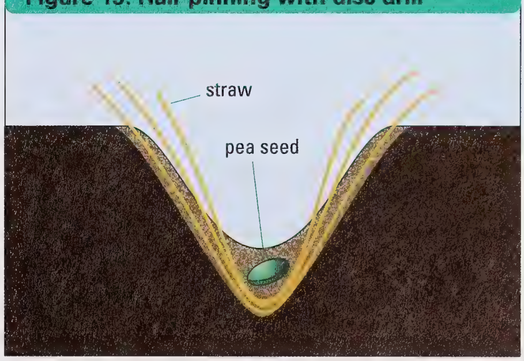
Field pea is well adapted to direct seeding or reduced tillage systems[1]. For best results, follow the recommendations in this section on:

- residue management
- seeding management
- weed control
- fertilization

Residue Management

Proper straw and chaff management in the fall before seeding a pea crop is critical. Heavy straw conditions can create seeding problems such as hair pinning[2] (Figure 19) with disc openers or plugging between the shanks of an air seeder. Thick layers of chaff may also cause phytotoxicity[3] to the next crop.

Figure 19. Hair pinning with disc drill



Field pea, a cool-season crop, is one of the least sensitive crops to the cooler soil temperatures associated with heavy crop residue. That makes it a great candidate for direct seeding. Keep these points in mind:

- even and wide distribution of residue with a durable straw chopper and chaff spreader is vital
- combine chaff collectors are now commercially available
- to avoid plugging shanks, stubble height should be the same or less than the shank spacing of the seeding tool

Proper rotational planning can also assist in managing heavy residue:

- avoid planting high-residue crops back-to-back
- include forages in the crop rotation
- periodically bale and remove straw
- utilize semi-dwarf (short straw) varieties in the rotation

Notes

[1] Direct seeding is usually defined as seeding into standing stubble. In this section, it will also be refered to as reduced tillage.

[2] Hair pinning refers to a condition where the seed is pushed down onto the straw layer by the opener, creating a wicking effect, where there is poor seed-to-soil contact and, as a result, patchy or poor germination of the pea crop.

[3] Phytotoxicity is the phenomenon of reduced growth and yields of the next year's crop due to toxic compounds leached from the residue and/or microbial activity that produces toxic compounds during breakdown of the residue.

Seeding Management

Field pea should be the first crop seeded in the spring, since early seeding results in higher yields and often better quality. Early seeding of field pea – ideally in late April and early May – should also result in an early harvest.

- seed placement or depth should be checked while seeding to ensure that the seeding depth targeted for is being achieved
- packing to improve seed-to-soil contact is important – but don't overdo it, especially in heavy, wet clays (this can be especially detrimental if air temperatures rise quickly and the soil bakes and crusts)
- use seed with both high germination and vigor (see germination and vigor section for more detail)
- aim for a seeding rate of seven viable plants per square ft. – calculate the seeding rate for every variety seeded, as well as for every seedlot used

Weed Control

In a direct seeding system, weed control should start in the fall. Various weed species react differently to the types of tillage systems. Increased tillage favors stinkweed, wild oats and chickweed. Other weeds – such as bluegrass, clover, groundsel, and smartweed – germinate better under reduced tillage.

Winter annuals (stinkweed, flixweed, narrow leaved hawk's beard and shepherd's purse) and perennial weeds (quackgrass, Canada thistle and sow thistle) increase and become more visible under direct seeding. Wild oat and green foxtail populations tend to decrease after continuous direct seeding.

- a pre-harvest application of glyphosate (Roundup®, Touchdown®, Laredo®, Wrangler®, Renegade®, Victor®) effectively controls perennial weeds such as Canada thistle, sow thistle, quackgrass, toadflax and dandelion
- a fall application of a 2,4-D or MCPA from mid-October to freeze-up is critical to control winter annuals – these can be tough to control in the spring, especially if allowed to grow past bolting stage
- do not apply 2,4-D or MCPA in the spring for winter annual weed control prior to seeding pea as this approach can harm pea plants
- never apply dicamba or dicamba mixtures (Banvel®, Rustler®) as a winter annual weed control measure prior to growing a field pea crop
- pre-seeding burnoff with glyphosate can be effective for many winter annual weeds provided environmental conditions are conducive to performance and the weed is at a young growth stage – good soil moisture, high temperatures, bright, sunny days and long day lengths enhance glyphosate activity
- surface-applied fall pre-emergent herbicides are at least as effective as conventional treatments (this may be due to the higher moisture retention in direct seeding systems)
- apply herbicides early; from the three to four-node pea growth stage
- follow the growth stage of the crop, rather than spraying by the calendar (see Weed Control under the Post-Seeding Considerations section for more information)

Fertilization

Less tillage means slower breakdown of crop residues, such as straw and chaff, as well as soil organic matter. Nitrogen contained in crop residue is tied up for a longer time in a direct seeding system and is less available to plants. If the field pea crop is properly inoculated, however, this should not pose a problem.

- spring banding is the most efficient method of applying fertilizer – banding fertilizer in a pea crop is better than broadcasting, since less fertilizer will be available for weed growth, especially if the fertilizer is placed close to the seed
- never sacrifice seed placement for fertilizer placement – proper seeding depth and soil-to-seed contact is critical
- in heavy clay soils, seed and fertilizer separation may be reduced due to soil lumping
- high seeding speeds may affect seed and fertilizer separation by collapsing the banding trenches
- too much seed-placed fertilizer can hurt crop emergence, cause severe crop damage and/or increased days to maturity
- studies on seed-placed phosphorus using double disc openers suggest a maximum of 30 lb./acre of P_2O_5
- soil moisture conditions, row width and width of spread, soil texture and fertilizer type dictate what rate of fertilizer can be safely placed with the seed (higher moisture levels allow for more seed-placed fertilizer)
- row width and width of spread of the seeding tool determines the Seedbed Utilization (SBU) or how fertilizer is scattered in relation to the seed - wider row spacings lead to reduced seedling emergence and yield loss (the same holds true for narrow spread patterns)
- the higher the percentage of Seedbed Utilization (SBU), the more fertilizer may be placed with the seed

Use this formula to calculate Seedbed Utilization (SBU):

$$\%\ \text{seedbed utilization} = \frac{\text{width of seedrow} \times 100}{\text{row spacing}}$$

Land Rolling Pea Fields

There are two main reasons for rolling a pea field:

- to push rocks down to the soil surface
- to break up dirt lumps and eliminate dirt problems during straight combining

Most producers have found that rolled fields make swathing pea crops much easier, since a firm soil surface results in less plugging.

Pea field before rolling

Pea field after rolling

Table 30 shows information on the effects of early and late rolling and on the use of water ballast on pea yield. No significant differences were observed from land rolling trials compared to the check (not rolled) treatment. This result suggests that when properly done, light rolling (no ballast) will not reduce pea yields.

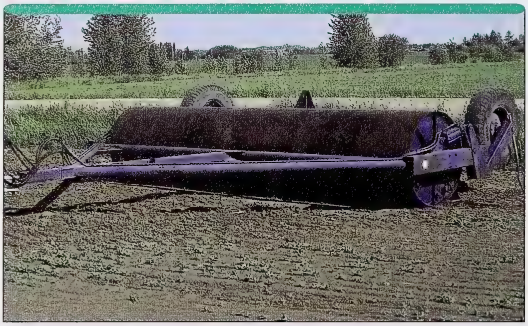
Table 30. Effects of rolling pea fields

Land Rolling Treatments	Yield as % of CHECK (not rolled) Plots	
	1993 (average of 2 sites)	1994 (average of 4 sites)
Early/light rolling	99.8	94.2
Early/heavy rolling	103.2	94.5
Late/light rolling	101.2	102.5
Late/heavy rolling	96.5	94.9
Check/not rolled	100	100
Significance	ns	ns

Source: Lopetinsky and APGC - Zone 3FFF - O.F.D. #93-F001-5
Note: Early rolling was done immediately after seeding, and late rolling was at the two to three-node stage. Light rolling was a 42-inch roller without water ballast while the heavy rolling was with water ballast.

Overall, research on rolling suggests the following recommendations:

- roll pea fields soon after seeding and when the soil surface is dry – this will also ensure the field is ready for herbicide applications at the correct node and weed growth stages (spraying should normally be done before rolling, if the crop is advanced)



Crop/field roller

- late rolling of pea fields (after the fifth node stage) is not recommended – this may result in bruising of the pea leaves, stem breakage and increased disease levels
- when stuck with late rolling **and** late spraying, when pea growth is advanced, spray first and roll the field **three to four days** later – if the herbicide has a wide window for application, roll the pea field first, as rolling causes less stress on the plant than broadleaf herbicides
- if wind or water erosion is a concern, rolling should be done just after the pea crop is up – at the two node stage
- never roll pea fields in the morning – rolling wet pea leaves spreads disease
- water ballast in the roller is not generally necessary – some producers, however, add water ballast on older zero-till sites to level out the disturbed soil
- rolling headlands results in double rolling and is not necessary (these areas are generally much firmer) – the danger of headland rolling is that it will thin out the pea crop

Pea Irrigation and Water Use

Pea responds well to irrigation and can also be grown under dryland conditions. Field pea has a high water use efficiency and can use moisture in a root zone of about 0.80 m or 2.6 ft. This means it can effectively use moisture on stubble where it is not fully recharged but cannot make use of soil moisture below 1.0 meter.

In the Brown or Dark Brown soil zones, chickpea may prove a useful alternative to pea as chickpea roots deeper than pea and is able to extract more moisture from the soil than a pea crop. Pea is also sensitive to salinity and to waterlogged soils.

Irrigation of Pea Crops

Water use experiments conducted with pea at Vauxhall, Alberta, in 1976 show:

- the maximum average water use is 6 mm (0.24 in.) per day, and this occurs just after flowering
- pea is sensitive to water stress at all stages of growth – a safe depletion of available water should not exceed 30 per cent until pod filling is completed

Water use experiments conducted with pea at Brooks, Alberta, from 1974 to 1976 show:

- water use efficiency was 21 to 28 kg/ha. of total dry matter per mm of water and about 10.9 to 13.3 kg/ha. of seed per mm was produced
- the harvest index (weight of seed/weight of total dry matter) was about 0.46 to 0.51, and this ratio increased when optimum irrigation was supplied
- total water use of pea at Brooks varied from 410 to 440 mm (16 to 17.5 inches) to obtain maximum yield of over 4500 kg/ha. (4000 lb./ac.)
- these processing pea experiments were conducted with Dark Skin Perfection, a late determinate growth variety – early determinate varieties such as Sprite or Sweet 11 required about 80 per cent of the amount of water needed for a late variety
- protein content in pea is maintained under increasing amounts of irrigation (with cereals, protein content declines when irrigation increases)

Salinity and Drainage

- pea is sensitive to salinity
- an Electrical Conductivity (EC) of 4 dS/m or higher in the top 30 cm (1 ft.) of soil severely reduces field pea growth
- poor drainage is also damaging, especially if the waterlogging occurs just before flowering (Greenwood and McNamara, 1985)
- if irrigating by flood irrigation, use short sets of not more than three to five hours, and do not irrigate after the vines collapse

Water Use Under Dryland Conditions

Data from Miller and McConkey, 1998, show that pea is not as effective in using soil moisture below 0.60 m as wheat, chickpea or mustard. Other data, from dryland conditions in Saskatchewan (Miller et al, 1998), indicate pea has water use efficiency equal to wheat on fallow and better on stubble.

Semi-leafless varieties of pea are reported to have similar water use as conventional fully-leafed pea in experiments in New Zealand by Zain et al, 1983, and in Spain by Martin et al, 1994. Other authors report differences between varieties in drought tolerance and in water use.

Yield, water use and effective rooting depth of wheat, pea, chickpea, lentil and mustard when grown on fully re-charged fallow at Swift Current and Stewart Valley 1996-97 derived from P. Miller and B. McConkey.

Variety	Yield (kg/ha.)	Water use x soil depth			
		0-0.60	0.60-0.90	0.90-1.20	Sum
		(mm of water)			
CWRS wheat	3102 a+	69	35 a	20 a	124 a
Yellow pea	2632 b	66	15 c	8 b	89 b
Desi chickpea	1915 c	81	30 ab	18 a	130 a
Laird lentil	1456 cd	71	20 c	8 b	99 b
Oriental mustard	1422 d	71	28 b	20 a	119 a

+ Values within a column followed by the same letter are not statistically different (P=0.05)

Alternative crop yields and water-use efficiency (WUE) averaged for tillage systems in fallow and wheat stubble phases at Swift Current 92-94, 96 and Assiniboia 1994-95. Derived from Miller et al, 1998.

Crop	Fallow			Stubble		
	Seed yield (kg/ha.)	WUE (kg/ha./mm)	Water used (mm)	Seed yield (kg/ha.)	WUE (kg/ha./mm)	Water used (mm)
Dry pea	2957 a+	9.52 a	311	2598 a	9.26 a	281
DWRS wheat	2890 a	9.00 a	321	1904 b	6.62 b	288
Mustard	1837 b	5.29 b	347	1098 c	3.97 cd	277
Desi chickpea	1635 b	4.50 bc	363	1243 c	3.97 cd	313
Lentil	1546 bc	5.03 b	343	1221 c	4.50 c	271
Safflower	952 cd	2.38 cd	400	885 c	2.38 de	372
Dwarf sunflower	941 cd	2.65 cd	355	851 cd	2.91 cde	292
Dry bean	638 d	2.12 d	301	381 d	1.59 e	240

+ Values within a column followed by the same letter are not statistically different (P=0.05)

Post-Seeding Considerations

Weed Control

Weed Control the Year Before Pea

Compared to most other crops in the rotation, pea is a very poor competitor with weeds, and weed control is necessary the year before growing pea to produce a high-yielding crop.

- choose clean fields, free of herbicide residues
- control perennial weeds (Canada thistle, sow thistle, quack grass, dandelion and toad flax) with a pre-harvest application of a glyphosate product the year before pea, and apply when weeds are actively growing under proper temperature, good moisture and bright light (products include: Roundup®, Laredo®, Renegade®, Touchdown®, Wrangler® and Victor®)

Plant stunting – herbicide residue

- under direct seeding systems, a spring burn-off application of glyphosate may provide effective weed control – delayed seeding to allow spring weed growth may result in high flower blast and lower pea yields
- cases have been seen of serious residue herbicide damage of field pea caused by seeding on rented land with no herbicide records or history – so ensure records on all fields are kept to monitor residual herbicides (even reduced rates of residual herbicides can cause serious injury to the pea crop the following year)

Control of Winter Annuals

With more use of direct seeding, farmers have seen shifts in weed communities. Weeds traditionally controlled by cultivation – such as winter annuals and perennials – are increasing. Both winter annuals and perennials are poorly controlled by in-crop herbicides.

Table 31. Herbicide carryover and pea re-cropping restrictions

Pea Re-cropping Restrictions for Herbicides in Alberta 1998		
Trade Name	**Chemical Name**	**Pea Re-cropping Restrictions**
Accord®	quinclorac	Wait 10 months before seeding pea.
Ally®	metsulfuron methyl	On soils with a pH 7.5 or lower, wait 22 months or do a field bioassay.
Amber®-Dark Brown & Brown soil zones only	trisulfuron	Wait 34 months before planting pea. Field bioassay recommended.
Assert®	imazamethabenz	In Dark Brown soils, do not plant in the year following applications.
2,4-D/MCPA	phenoxy	2,4-D should not be applied in the spring, either pre-emergence or prior to seeding. Use of high rates of 2,4-D or MCPA in the fall as spot treatments to control Canada thistle can carry over and affect pea sown early in the following year.
Banvel®	dicamba	Do not grow pea the year following a 1 L/ac. rate of application.
Curtail M®	clopyralid + MCPA ester	Do not seed pea for one year following treatment year.
Glean®	chlorsulfuron	No longer registered. Residues may last up to 5 years. Field bioassay recommended.
Lontrel®	clopyralid	Do not seed pea the year after treatment.
Muster®	ethametsulfuron-methyl	Wait 22 months before planting pea.
Poast Flaxmax®	clopyralid + sethoxydim + MCPA	Do not seed pea for one year following treatment year.
Prestige®	fluroxypyrt + clopyralid + MCPA	Do not seed pea for 22 months following treatment.
Prevail®	clopyralid + tralkoxydim + MCPA	Do not seed pea for one year following treatment year.
Refine Extra®	thifensulfuron methyl + tribenuron methyl	Wait two months before planting pea.
Tordon 101 Mixture®	picloram + 2,4-D	Do not plant until at least the fifth growing season after application. Field bioassay recommended.
Unity®	trisulfuron + bromoxynil	pH less than 6.4, wait 10 months. pH greater than 6.5, wait 22 months.

- problem perennials include quackgrass, Canada thistle, perennial sow thistle, toadflax and dandelion
- common winter annual weeds include flixweed, downy brome, shepherd's-purse, stinkweed, narrow-leaved hawk's-beard, blue bur, dog mustard, ball mustard, common groundsel, yellow whitlow grass and common pepper grass

Winter annual growth habits make them difficult to control. Winter annuals germinate in the fall and overwinter as rosettes, producing seed the following year. If these weeds are allowed to bolt the following year, prior to herbicide application, control becomes nearly impossible. Therefore, timing of the herbicide application for control of winter annuals is critical.

- if a Group 4 herbicide (such as 2,4-D, MCPA) is being used, apply in the fall to protect against residues from spring applications
- an early spring application of these herbicides has been recommended for winter annual weed control in cereals, but these herbicides can be taken up from the soil by pea and can cause serious injury
  - under ideal conditions of warm moist soil, these herbicides are degraded microbially to safe levels in one to four weeks after application
  - under dry, cool soil conditions, these herbicides can persist for much longer

For further information, consult Agdex 142/642-1, Weed Control in Pea – Preparing for Your Pea Crop or Agdex 142/642-2, Herbicides for Direct Seeding Weed Control in Field Pea.

Herbicides Recommended for Field Pea

Pre-plant incorporated herbicides

- Trifluralin
- Edge®
- Sencor® + Edge®
- Sencor® + Trifluralin
- Avadex®

Post-emergent herbicides

- Basagran®
- MCPA Amine
- MCPA Na Salt
- Sencor®
- Pursuit®
- Odyssey®
- Tropotox Plus®

Post-emergent herbicides (grassy weed control only)

- Poast®
- Hoe Grass 284®
- Venture®
- Assure®
- Fusion®
- Select®

Post-emergent tank mixes

- MCPA Na Salt + Sencor®
- Full rate Pursuit® + full rate Poast®
- Full rate Pursuit® + full rate Venture®
- Half rate Pursuit® + full rate Select®
- Half rate Pursuit® + full rate Poast®

Always read and follow label recommendation, and contact the herbicide company for further information about the performance of the herbicides on specific weeds.

For full information, consult Agdex 606-1, Crop Protection or Agdex 142/642-4, Herbicides for Use in Pea.

In-Crop Weed Control

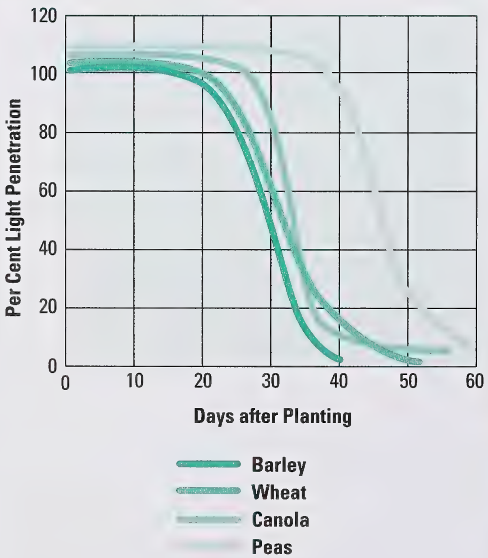
- use good seeding practices to produce a healthy, vigorous and uniform seedling stand
- know your weeds – what one person calls pigweed may actually be lamb's-quarters (post-emergent herbicides such as Pursuit® perform well on pigweed but have very poor performance on lamb's- quarters)
- the best way to check a weed's identity is to compare weeds using a weed seedling identification guide – consult the ***Weed Seedling Guide,*** **Agdex 640-9**

Late herbicide application (pea in flower)


Grassy weed pressure in a pea crop

- timing for effective herbicide application is critical, not only with respect to the growth stage of the field pea plant but for the weeds as well – in general, the smaller and younger the weed, the better the control achieved
- because field pea does not provide a competitive canopy early in the season, weed growth will be greater and more visible in an emerged pea crop – it takes a full two weeks longer than other crops for the pea crop to develop a canopy to decrease light penetration for weed growth as shown in Figure 20.

Figure 20. Light penetration into crop canopy



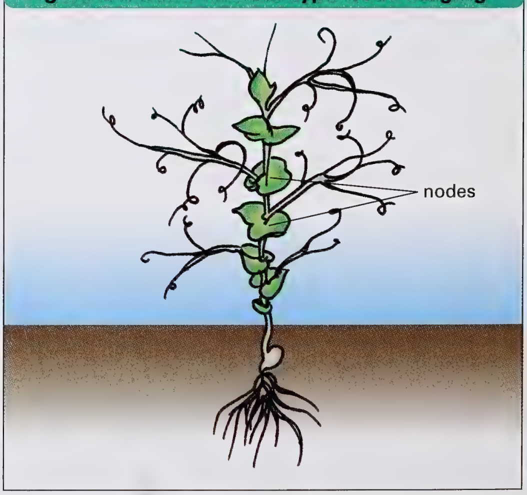
Node Staging

- a pea plant can produce two nodes in seven days under optimum conditions
- if you are using a post-emergent product, know the correct node stage of the pea plant for safe application – most broadleaf weed control products perform best at the two to five-node stage


Start post-emergent herbicide application

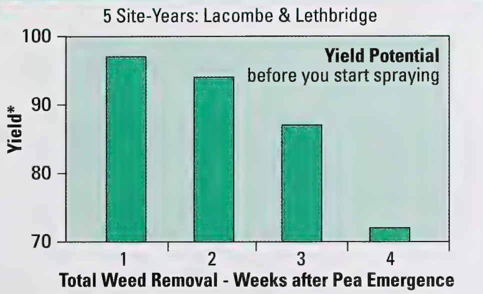
- products such as MCPA Na salt or Tropotox Plus must be applied before the five-node stage, or severe damage can occur to the crop – the earlier these products are used, the safer they are on the crop; the exception is Pursuit, which can be used up to the six-node stage of the field pea plant
- node staging – not the height of the pea plant – determines time of spraying (under drought conditions, a pea plant can reach five nodes and still be only 3 in. or 7.5 cm tall)
- when counting node stages on a pea plant, the first leaves (called scale leaves) are very small and close to the stem – these are not counted (see Figure 21)
- the point where the first true leaf joins the stem is counted as the first node; the second node occurs where the second leaf joins the stem and so on

Figure 21. Semi-leafless type node staging



- spray early to remove weed competition as shown in Figure 22
- pea yield potential declined every week spraying was delayed after pea emergence

Figure 22. Weed removal timing effects on pea yield



*%Yield is compared to removal at 0 weeks after crop emergence.
Source: Harker, Agriculture and Agri-Food Canada (AAFC) – Lacombe, 1998

- application of broadleaf herbicides requires high water volumes to reduce crop stress (follow product label instructions to ensure crop safety)
- under wet conditions, season-long residual herbicides (Pursuit®, Odyssey® or Sencor®) can be more effective than contact-only herbicides
- broadleaf herbicides like MCPA (amine or sodium salt), Tropotox Plus® and Basagran® only suppress thistles in the pea crop
- there are currently two choices for one-pass, in-crop broadleaf and grassy weed control – to avoid crop injury, these herbicides (Odyssey®, Pursuit®) should be applied with strict attention to the pea crop's staging (also note that both Odyssey® and Pursuit® have cropping restrictions the following year)

Herbicide Tank Mixes for Weed Control in Pea

Tank mixes, or herbicide products offering both broadleaf and grassy weed control, should be applied when either weed group is nearing its maximum growth stage for good control.

- never use unregistered mixes or 'cocktails' in a pea crop – this may result in reduced or no herbicide activity, poor weed control and severe injury to the pea crop
- surfactants can affect both weed control and crop safety – the use of an incorrect surfactant is very risky
- all adjuvants are not equal – producers changing adjuvants, or even altering adjuvant rates in the herbicide or tank mix, should expect variable results in weed control
- registered tank mixes for broadleaf and grassy weed herbicides for use on field pea include: Sencor® plus MCPA Sodium Salt; Pursuit® plus Poast® or Select®; and Treflan®, Rival® or Edge® plus Sencor®
- herbicide mixtures of Poast®, Venture® or Select® with Pursuit® are more effective in controlling cereal volunteers and heavy wild oat infestations than Pursuit® alone

For further information on herbicide tank mixes, consult Agdex 142/642-3, Herbicide Tank Mixes for Weed Control in Field Pea Crops. Also consult Agdex 606-1, Crop Protection.

Split Applications for Weed Control in Pea

Split applications – that is, separate applications of herbicides on the same field – may give better weed control at a lower cost under the following conditions:

- **grassy weeds are well established but broadleaf weeds have not emerged**: in some years, cold spring conditions and low soil temperatures result in rapid growth of grassy weeds (like wild oats) but slower growth of broadleaf weeds
- **grassy weeds occur mostly in patches**: patch spraying with a grassy weed control chemical in a second pass will be more economical than using a tank mix over the entire field
- **weed populations vary throughout the field**: more economical weed control can be achieved by varying the rates of either the grassy or broadleaf herbicide – this result would not be possible with a tank mix

Risks of Split Applications

- most post-emergent herbicides are applied in the two to six-node stage, which only allows for a two-week window to complete all herbicide applications
- in years with rainy or windy weather, the second herbicide may be applied too late and increase the risk of crop injury and reduce weed control
- split applications may cost more
- delayed herbicide applications are usually less effective, and a late application may be after substantial yield losses from weeds have already occurred

Weed Control Summary

- control perennial weeds (thistles, quackgrass) the year before seeding pea with a pre-harvest glyphosate product
- to avoid having residual herbicide damage to the pea crop, keep herbicide records on all fields

Poor weed control

- proper seeding management will help produce a vigorous, uniform pea crop, for better competition with weeds and easier herbicide timing
- know your weeds – start scouting fields at pea emergence for weed types, and match the herbicide to the weed types
- know your pea node stages – most herbicides are applied between the two to six-node stage with the best time being the three to five-node stage
- spray early to remove weed competition
- to minimize crop stress, use higher water volumes of 15 gallon/acre (70 litre/acre) with broadleaf herbicides
- watch for other broadleaf herbicide residues in the sprayer tank – thoroughly clean the sprayer before spraying a pea field

Diseases of Field Pea

This section outlines the key diseases in field pea, along with information on how they can be recognized and controlled.

Soil-Borne Diseases

Seedling Blight, Seed Rot and Root Rot

This disease complex is caused by a number of soil-borne fungi: *Pythium* species, *Fusarium solani* f.sp. *pisi*, *F. oxysporum* f.sp. *pisi* and *Rhizoctonia solani*. They can attack pea plants – either individually or collectively – any time between germination and maturity. Together they cause a complex of seed rot, damping off, seedling blight, root and foot rot diseases.

In the field, it can be difficult to tell these diseases apart – this information on disease identification should help.

Fusarium Root Rot

- caused by *Fusarium solani* (Mart.) Sacc. f. sp. *pisi* (Jones) Snyd. and Hans.
- yield losses of 26 per cent to 57 per cent have been reported in both dryland and irrigated areas
- fusarium root rot is most prevalent under poor crop rotations, high soil temperatures (22° to 30° C), moist soils, acidic soils (pH 5.1 - 6.2) and low fertility
- soil compaction by farm machinery also increases both incidence and severity

Fusarium root rot

Symptoms

Fusarium foot rot

- reddish brown streaks initially develop on the primary and secondary roots
- these eventually join together to form a dark reddish-brown color on the primary root up to the soil line
- greying, yellowing, death of lower foliage and stunting can occur if infection is severe
- foliar symptoms often appear following warm temperatures and heavy rainfall

Fusarium Wilt

- caused by *Fusarium oxysporum* Schl. f. sp. *pisi* (Van Hall) Snyd. & Hans.
- of the disease's many races, races 5 and 6 are most important in Western Canada
- pathogen can be seed or soil-borne and can infect soils for 10 or more years
- races 5 and 6 thrive under soil temperatures of 20° to 21° C

Symptoms

- race 5 and 6 symptoms are most often found in small, circular patches in fields
- in roots cut longitudinally, a yellowish, orange color is seen in the vascular tissue, which can extend into the basal area of the stem
- other symptoms include:
  - downward curling of the leaves and stipules
  - thickening of the basal internode and brittle leaves and stem
  - yellowing of the leaves progressing from the base of the plant to the top of the foliage (plants often die due to loss of the root system)

Pythium Root Rot

- caused by a number of different *Pythium* species. In Alberta, *P. irregulare* and *P. ultimum* are the most common
- infection very dependent on seed quality – cracked seeds leak more nutrients and are more likely to attract Pythium and be infected than intact seed
- more prevalent in cool, wet, poorly drained soils

Symptoms

- seeds are rotted – when removed from the soil, they emerge with a layer of soil around them (this is full of whitish, threadlike fungal hyphae)
- emerging plant and roots, if produced, may be soft and watery; cotyledons may or may not be rotted
- germinating seeds are only susceptible for 48 to 72 hours – once the root emerges, the seed is no longer susceptible to infection (new developing tissue, however, remains susceptible)

Pythium root rot

- infection can occur at the tip of feeder roots where young tissue can be destroyed – this can lead to root pruning and/or reduction in length
- depending on the severity of the infection, seedlings may become stunted and chlorotic and collapse as the root base decays and turns tan to light brown

Pythium root rot

- infected plants tend to lack vigor and often yield poorly

Rhizoctonia Root Rot

- caused by *Rhizoctonia solani* Kuehn.
- seedlings generally less susceptible as they get older
- high soil temperatures (24° to 30° C) are known to cause higher rates of infection

Symptoms

- infection occurs (and symptoms appear) close to the soil surface
- symptoms on seedlings first appear as water-soaked lesions that eventually turn reddish brown
- plant's growing point may die as it emerges from the ground – this can lead to multiple shoots emerging and then dying
- on older plants, symptoms appear as reddish-brown sunken lesions on the lower stem, which can cause girdling and often leads to stunted plants

Prevention and Control of Seedling Blight, Seed Rot and Root Rot

Since these root rot pathogens are rarely found individually in a field, control measures should aim to control them all. Possible prevention/control measures include:

- a four to five-year rotation out of pea or other susceptible hosts (alfalfa and clovers)
- use seed with high vigor
- practise good soil fertility, liming of acid soils and ripping to reduce soil compaction
- avoid herbicides such as MCPA, MCPB or a mix of MCPA and MCPB – these herbicides cause plant stress and make root rot more severe
- Thiram 75WP® (thiram), Captan FL® (captan) and Vitaflow 280 are registered for control of seed decay, damping off, root rot and seedling blight

- Apron FL® (metylaxyl) is registered for control of seed rot and seedling blight specific to *Pythium* species and can be mixed with Thiram 75WP® to give a broader control spectrum

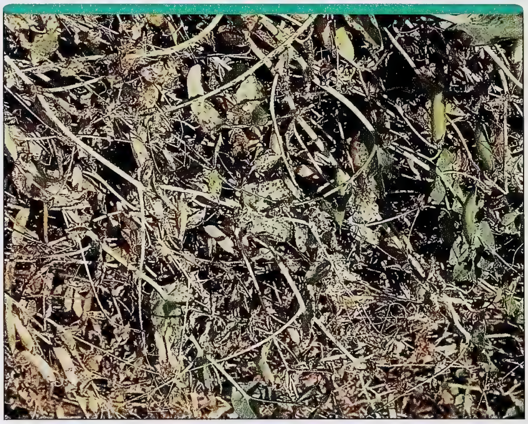
Foliar Diseases

Ascochyta/Mycosphaerella Blight

- this disease complex is caused by three fungi: *Mycosphaerella pinodes* (Berk. & Blox.) (the perfect stage of *Ascochyta pinodes*), which causes blight; *Ascochyta pisi Lib.*, which causes leaf and pod spot and *Phoma medicaginis* var. *pinodella* (Jones), which causes foot rot
- *M. pinodes* is the most common on field pea in Western Canada – average yield losses run to 10 per cent, but losses of up to 80 per cent have been reported
- the three species often occur together and can be difficult to tell apart
- for most pea varieties, expect a 5 to 6 per cent yield reduction for every 10 per cent of the stem area affected
- these pathogens can be seed, stubble or soil-borne – seed-borne infection by *M. pinodes* is considered to be the primary source of infection in virgin pea fields
- *P. medicaginis* var. *pinodella* and *M. pinodes* are both quite persistent, surviving on pea straw fragments and in the soil
- when moisture and temperature conditions are favorable, residual pycnidia from *M. pinodes* mature, new pycnidia develop and pycnidiospores are released – these can infect healthy plants by rain splash (ascospores are also produced and can be carried by wind for a kilometer or more)
- *A. pisi*, on the other hand, competes very poorly with other microflora in the soil and overwinters very poorly – the main source of infection is from seed-borne spores

Ascochyta blight

Ascochyta blight



Mycosphaerella blight

Symptoms

Mycosphaerella blight

- *A. pisi* lesions are partially sunken, tan colored and surrounded by a well-defined dark brown margin:
  – circular lesions are found on pods and leaves while lesions on stems are more elongated
  – numerous pycnidia are usually found in the lesions
  – lesions of *A. pisi* are rarely found on any plant parts below the soil line
- if lesions on leaves, stems and pods are widespread and severe, *M. pinodes* is the cause
- if lesions are severe on roots, *P. medicaginis* var. *pinodella* is the cause
- *M. pinodes* produces small, brown to purplish, irregular flecks without definite margins, initially appearing on pods, leaves, stems and the cotyledonary area – these lesions enlarge if weather conditions are favorable (15° to 18° C and high humidity)
- dark-brown to black specks (pycnidia) are eventually produced and form a distinct concentric tan and brown ring pattern as the lesions enlarge – this is often more pronounced on leaves and pods than on other plant parts
- lesions developing on stems tend to form long, wide purple to bluish-black streaks that eventually coalesce and may completely girdle the stems, pod attachments or tendrils – these streaks are more common near the nodes and on the lower portion of the stem

- early pod infection can lead to seed infection, which may show no visible symptoms if infection is light, to varying degrees of shrinkage and discolouration if severe
- under drier conditions, the concentric ring pattern of the symptoms is less pronounced and may show up only as a uniform yellowing of lower leaves – if the blossom becomes infested, girdling of the sepal often occurs, leading to pod drop or distortion

Prevention and Control

- have pea seed examined for *Ascochyta* presence by an accredited seed lab
- use only pathogen-free seed – if pathogen-free seed cannot be found, use seed with as low a level of *Ascochyta* as possible, and have the seed treated
- seed treatment with Thiram 75WP®, although not registered as a control, can give excellent control of seed-borne *M. pinodes* on pea
- avoid seeding next to any previous year's pea fields since spores can spread by wind
- Bravo 500® (chlorothalonil) has recently been registered for use on field pea in Alberta to prevent infection by Mycosphaerella blight – apply in the early bloom stage and repeat up to three times at 10- to 14-day intervals if conditions favor disease development (warm and humid)
- bury all crop residue, to prevent the fungus being spread by wind and rain
- have a four to five-year rotation between pea crops

Sclerotinia Rot

- caused by *Sclerotinia sclerotiorum* (Lib.) de Bary (often called white mold or pod rot)
- prevalent when pea and canola are grown in the same rotation
- dense canopies and high humidity favor sclerotinia outbreaks
- ascospores cannot infect pea plants directly because to germinate, they need a source of dying tissue (such as stamens or flower petals) – these are then colonized by threadlike running hyphae, especially under moist conditions
- ascopores can be released over long distances (up to several kilometers) and long periods of time
- the critical infection period is during the flowering stage
- when pea seed is harvested, sclerotia are either harvested with the seed or fall to the ground with the vines – only sclerotia in the top 6 cm of soil can produce


Sclerotinia rot

apothecia, sclerotia buried deeper remain dormant and can survive in the soil for five to seven years, until conditions for apothecia formation are favorable

Symptoms

- first sign is the appearance of a light brown discolouration on the stem, leaves or pods
- with pod rot, this occurs at the base of the style with a small water-soaked lesion appearing on green tissue at the end of the pod
- with stem rot, the symptoms are more common in the node area
- whitish, threadlike mats develop over the affected areas and, over time, cause the tissue underneath to turn soft and decay – black, hard bodies (sclerotia) form in the mat and within the stem and pods
- affected plants often appear wilted and ripen prematurely due to rotting stems – lodging is common in affected areas
- when humidity is high and moisture is abundant (such as within a


Sclerotinia rot


Sclerotinia rot

thick canopy), tan, fleshy, golf-tee shaped apothecia emerge on the sclerotia – numerous ascospores develop within the apothecia and are released into the air to infect nearby healthy plants

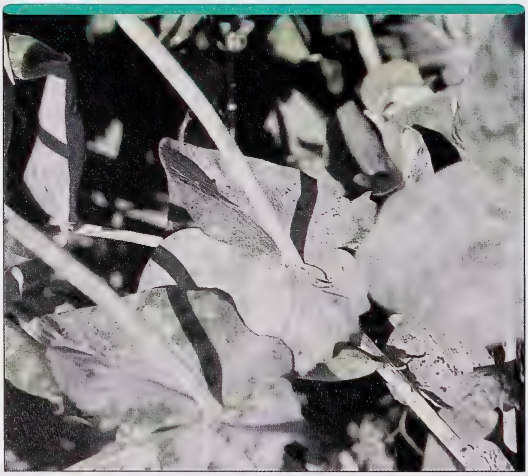
- lesions appear four to five days after infection, and within eight days, dark to greyish-brown lesions ranging from 1 to 5 mm can be seen on the infected tissue

Prevention and Control

- four to five-year rotation out of susceptible crops (canola, mustard, sunflower, dry bean)
- bury sclerotia bodies deep
- planting semi-leafless pea varieties to allow greater air flow through the canopy
- no fungicides are registered for use on field pea, but you can control this disease in canola - Benlate 50WP® (benomyl) and Rovral® (iprodione) are registered

Powdery Mildew

- caused by *Blumeria pisi* f.sp. *pisi*
- borne on seed or stubble
- seldom a problem until late in the season when environmental conditions are favorable
- summer rains damage the fruiting bodies, causing them to burst instead of germinate – in late-summer or early-fall, when dews occur without rain, the disease can spread very quickly
- severe infections reduce plant weight, seed weight, number of seeds per pod, pods per plant and plant height



Powdery mildew

Symptoms

- first appear as off-colored spots on the upper surface of the lowest and oldest leaves
- spreads rapidly to cover entire surface of leaves, stems and pods with a fine, powdery, bluish-white mildewy growth – underneath the mildew, the tissue often turns purplish

Powdery mildew

- as plants age, tiny pinhead size fruiting bodies (cleistothecia) develop – these are brownish at first, eventually turning black at maturity
- infection can also wither foliage – if infection occurs on the pods, penetration of the pod may occur and cause the seed to turn greyish-brown (severe infections can cause hollow seeds)

Prevention and Control

- seed early and use earlier maturing varieties
- use crop rotation practices
- bury the crop residue
- Kumulus DF®, an 80 per cent sulphur product is registered for prevention of powdery mildew on pea in Western Canada
- powdery mildew resistance is being incorporated into all new pea varieties and should be commercially available by the year 2004

Downy Mildew

- caused by *Peronospora viciae*, this disease likes cool, wet growing conditions and usually occurs on early-seeded crops
- pathogen can be seed or soil-borne and can survive in the soil for up to 15 years
- seed-borne infection often causes failed germination

Symptoms

- can be expressed systemically, locally (on leaves, tendrils and flowers) or as pod infections
- **systemic infections**: produce the most severe effects, causing stunting, distortion and the proliferation of white, cottony growth on the plant; profuse sporulation of the fungus occurs on the surface of the plant, and plants often die before flowering; if pods are produced, they are flattened, yellow, distorted and rarely set seed

Downy mildew

- **local infections**: appear as fluffy, white to bluish, cottony patches on the undersides of leaflets, while the upper sides turn yellow and die
- **pod infection**: first appears as blotches that become brown with green areas inside them, which cause small, brown, sunken spots on the seeds and if severe enough, can lead to seed abortion – a cottony growth can occur inside the pod and may contain numerous oospores
- infections on older plants may only appear as spotting on the leaves

Prevention and Control

Downy mildew

- use four- to five-year crop rotations
- practice deep burial of crop residue
- use of disease-free seed
- Apron FL®(metalaxyl) is not registered for control of downy mildew, but does provide some protection against soil and seed-borne infections

Bacterial Diseases

Bacterial Blight

- caused by a bacteria, *Pseudomonas syringae* pv. *pisi* (Psp)
- overwinters mainly as a seed-borne pathogen – seed can remain infected for up to three years
- rate of infection increases with soil moisture
- injury from hail, frost, wind, animals or machinery predisposes plants to infection
- secondary spread occurs by rain splash, wind, machinery, animals and irrigation

Bacterial blight

Symptoms

- shiny, water-soaked lesions initially appear near nodes and stipules – these spread to the stems, pod stems and tendrils and become darker in color
- the underside of leaves and stipules develop water-soaked spots that appear dark green to brown on the upper surface – with age, spots develop an angular shape with dark margins and a light colored, papery look in the center
- lesions appear translucent when held up to the light
- lesions on pods are also water-soaked at first, turning darker as they mature and becoming sunken – pods are often infected through the suture
- infected seeds may or may not show injury symptoms – watery, dark spots sometimes appear on the seed but usually no visible symptoms appear

Prevention and Control

- since the pathogen is mostly seed-borne, use disease-free seed
- seed production should be limited to more arid areas and irrigation should be avoided

Bacterial blight

Pink Seed

- caused by *Erwinia rhapontici*, this disease was first found on pea in southern Alberta in 1988
- bacteria enter pea pods through wounds caused by insects or mechanical injury and infect the seed inside the pods (seed quality is affected more than yield)
- more common in irrigated than in dryland pea fields because high humidity and mechanical injury from irrigation allow bacteria to penetrate through wounds to infect the pea plants

Symptoms

- tan to dark-brown lesions develop on pods only
- seed turns pink and is often shrivelled

Prevention and Control

- use disease-free seed

Pea Diseases of Minor Importance in Alberta

Aphanomyces Root Rot

- caused by *Aphonomyces eutiches* f.sp. *pisi*
- has yet to be confirmed in Alberta

Symptoms

- first appear on roots as straw-colored lesions that gradually spread – this causes a soft, watery, distinctive rot close to the soil line
- also leads to yellowing from the bottom up and stunting of the plant as it is unable to extract nutrients and moisture from the soil
- survives in soil for up to 10 years

Prevention and Control

- a four to five-year crop rotation will minimize damage from this pathogen

Thielaviopsis Root Rot

- caused by *Thielaviopsis basicola* Berk & Br. (also known as black root)

Symptoms

- often occurs with *Fusarium solani* – together they cause necrosis and blackening of the entire root system (occasionally, small black lesions also occur on the lower leaves of infected plants)
- high soil temperatures (28° C) favor this disease

Prevention and Control

- none known

Septoria Blotch

- caused by *Septoria pisi* West
- either seed or soil-borne, although seed transmission is not considered important
- temperatures of 21° to 27° C (with high humidity) favor development of this pathogen

Symptoms


Septoria blotch

- blotchy lesions with no distinct margins – these develop mainly on the lower, older leaves, pods and stems of the pea plant
- early blotches are yellowish-green, eventually darkening and enlarging as they mature (irregular in size and shape)
- entire leaves or stipules may be covered by blotches as they coalesce
- black specks (pycnidia) develop profusely over the surface of the affected areas

Prevention and Control

- a four to five-year crop rotation

Grey Mold

- caused by *Botrytis cinerea* Pers.exFr., grey mold can occur as a rot on pods, stems and leaves on pea plants or on fresh seed and pods in transit or storage
- infection occurs quickly under conditions of 16° to 21° C and 100 per cent humidity

Symptoms

- fuzzy, grey lesions are the first symptoms to appear on lower areas of the stem and spread until the entire lower foliage turns a fuzzy, grey color – this appearance is caused by the abundance of conidia produced on leaves and stems
- as the disease progresses, leaves become shrivelled and dry, and defoliation of bottom leaves occurs
- pod infection causes the most damage, and clinging blossoms provide a humid environment from which the tip of the young pod can be infected – small, oval, water-

soaked lesions develop and spread up the pod (these lesions are tan at first but turn greyish with age and often develop sclerotia in the form of small black specks)

Prevention and Control

- potassium fertilizer in potassium deficient soils reduces the severity of grey mold

Anthracnose

- caused by *Colletotrichum pisi* Pat
- seed or soil-borne
- warm temperatures, high humidity and recurrent rains all favor this disease

Symptoms

- pod lesions are circular and sunken with reddish-brown margins and reddish centers
- close examination of pod lesions often reveals fruiting bodies (acervuli) with orange-pink spores
- leaf and stipule lesions are oval, with brown margins and greyish centers
- stem lesions are elongate – they appear a copperish color when moist and greyish when dry
- severely diseased plants have an overall reddish-brown appearance

Prevention and Control

- use disease-free seed
- use four to five-year crop rotations out of pea or other hosts

Alternaria Blight

- *Alternaria alternata* (Fr.) Keissl. is the causal organism of this disease
- favored by prolonged high humidity (more than three days) and warm temperatures (16° to 24° C)

Symptoms

- foliar lesions are oval with, a concentric ring pattern inside – they are tannish-brown in the center and fade out towards the margins
- up to half or more of the leaves and stipules can be covered in lesions when an outbreak occurs
- pod lesions are smaller, raised and brownish in appearance – some slight stunting of pea plants can also occur

Prevention and Control

- crop rotation with non-host crops is the best means of prevention

Cladosporium Blight

- caused by *Cladosporium pisicolum* – often referred to as 'scab'
- seed or soil-borne
- occurs under conditions of high humidity and temperatures of 16° to 21° C

Symptoms

- first appear as inward curling as leaves unfold
- leaf lesions can be irregular or circular in shape – grey at first, eventually turning a tan to brown color (margins on lesions are thin and dark brown)
- shredding of leaves can occur as necrotic areas fall out or tear from wind – brownish, black lesions develop on most other plant parts except for the pods (cankers often form as these lesions age and crack)
- infected pods are often pockmarked and feel bumpy – dark, irregular pimples occur randomly on pods (seed infection can occur if pods are penetrated)
- severely infected seeds develop black, circular spots with well-defined borders – a light infection may show up as light, scattered black spots on the seed

Prevention and Control

- use disease-free seed
- use four to five-year crop rotations

Black Leaf

- caused by *Fusicladium pisicola*

Symptoms

- small, white spots on the underside of leaves are the first symptoms, and these spots penetrate the leaf as they enlarge, forming a concentric ring pattern progressing from tan in the center to grey to black at the edges – spots eventually darken, as specks (conidia) form on the underside of the leaf
- black, elongated lesions then streak the leaves – this starts with bottom leaves and progresses upwards (blackening is due to closely-packed conidia on the leaf surface)
- bottom leaves eventually turn completely black, dry out and become shredded in appearance

Prevention and Control

- use resistant varieties

Control measures for most common field pea diseases in Alberta					
Disease	**Inoculum Source**	**Favorable Conditions**	**Resistance**	**Chemical**	**Cultural**
Root rot	seed, soil	dry and moist soils	Genetic resistance is known but current varieties do not have it incorporated.	Captan FL® (captan)	Use high-quality seed and maintain a rotation of one pea crop every four or five years. Avoid other legumes in rotations with pea.
Seed decay and seedling blight	seed, soil	cool soils for Pythium, warm soils for Rhizoctonia	Genetic resistance is known but current varieties do not it have incorporated.	Thiram 75WP® (thiram) and/or Apron FL® (metalaxyl), Captan FL® (captan)	Use high quality seed and maintain a rotation of one pea crop every four or five years. Avoid other legumes in rotations with pea.
Ascochyta/ Mycosphaerella blight and foot rot	seed, soil	dry and moist soils	Multiple genes involved in attaining resistance. Development of a truly resistant variety will be a long time coming.	Bravo 500® (chlorothalonil)	Use high quality, disease-free seed produced in dry areas. Test seed for pathogen before planting. Maintain a rotation of one pea crop every four or five years.
Sclerotinia rot	soil	moist soil and high humidity	None available.	None available.	Maintain a rotation of one pea crop every four or five years. Avoid planting field pea after canola or other hosts such as bean, fababean, sunflower or mustard. Use semi-leafless varieties to create an open canopy.
Powdery mildew	soil	heavy dews without rain	Resistance is controlled by one or two recessive genes. Currently the varieties Highlight, Tara and AC Tamor are resistant.	Kumulus DF® (sulphur)	Early planting and frequent use of sprinklers in irrigation districts have been effective.
Downy mildew	seed, soil	cool, moist weather	Genetic resistance is known but current varieties do not have it incorporated.	None available.	Use of disease-free seed. Maintain a four to five-year rotation between pea crops. Deep burial of crop residue.
Bacterial blight	seed	warm and high soil moisture	Genetic resistance is known but current varieties do not have it incorporated.	None available.	Use high quality, disease-free seed produced in dry areas. Irrigation should be avoided and pesticide application should be by air to avoid mechanical injury.
Pink seed	seed	high humidity	None available.	None available.	Use high quality, disease-free seed produced in dry areas. Irrigation should be avoided and pesticide application should be by air to avoid mechanical injury.

Brown Spot

- caused by *Pseudomonas syringae* pv. *syringae*
- can be seed or soil-borne – does not survive for long on the seed but survives well in the soil
- 24° C and higher temperatures and high humidity favor brown spot

Symptoms

- initially appear as small, water-soaked lesions on leaves, petioles and stems – these eventually turn a tan color and appear burnt
- stem lesions are sunken and tend to elongate upwards – they often cause stems, petioles and growing points to become distorted
- infected leaves eventually dry up and fall off

Prevention and Control

- use of disease-free seed
- four to five-year rotaion out of susceptible crops (e.g. dry bean)

Viruses

More than 50 viruses are known to infect pea worldwide. Of these, only a few occur in Canada. Damage is rarely serious in Western Canada because of severe winters and a relatively short growing season.

Economically important viruses in North America are pea seed-borne mosaic virus, pea enation mosaic virus, bean (pea) leaf roll virus, pea streak virus and red clover mosaic virus causing pea stunt.

In the field, the pea aphid is the main vector of viruses from infected to healthy plants although other aphids are known to transmit viruses as well.

Symptoms

- may include downward curling of leaflets on seedlings, leaf mosaic, rosetting, shortening of internodes, chlorotic flecks or translucent lesions, upward curling of leaves, pod distortion and stunting
- tissue proliferation may occur along leaf veins and on pods
- pod set may be affected in some cultivars or distorted pods may develop with seeds that have split seed coats
- seed size and quality is often reduced
- delayed maturity may also occur
- some varieties may be infected and show no visible symptoms, but yield is reduced

Prevention and Control

- use of resistant varieties and virus-free seed
- control of aphid populations has not proven a reliable control method

Insect Pests of Field Pea

Generally, insects are not considered much of a problem in field pea crops in Alberta. Grasshopper and pea aphid are the only insects that could potentially cause economic damage, and both are more of a problem in hot, dry years. Blister beetle can occasionally be found in pea crops, but have not caused economic damage.

Grasshopper

Damage

- pea is not considered a preferred food of grasshopper, so they will normally attack other crops before moving into a pea field – with direct seeding of pea into a perennial forage stand, however, grasshopper can become a problem
- grasshopper can attack at any growth stage, but cause the most damage in the seedling stage – grasshopper nymphs will attack seedlings on the edge of a field as they emerge from ditches and fence rows in the spring
- economic threshold in pea is 10 grasshoppers per square meter

Control

- early seeding can help pea plants outgrow the susceptible stage before grasshoppers emerge
- no insecticides are registered for the control of grasshopper in pea

Pea Aphid

- adult is small (about 4 mm long) light green and long-legged
- can be wingless or have prominent, nearly transparent wings

Damage

- aphids overwinter as eggs in alfalfa and clovers, but more commonly blow in on warm southerly winds from the United States in June and early July
- aphids suck the sap from pea plants and weaken them and can also spread viruses from infected plants to healthy ones
- aphids reproduce more slowly under cooler conditions, where pea is generally grown in Alberta, so rarely cause problems
- economic threshold for spraying in pea is 10 aphids per plant in tenth node to early flowering stages

Control

- Cygon 4E® (dimethoate) and Lannate® (methomyl) are registered to control pea aphid
- heavy winds and rain can minimize pea aphid effect

Field pea diagnostic chart

The following chart will assist in field scouting. For more detail, please refer back to the appropriate section in this publication.

Field/Plant Symptom	Possible Causes
Poor or no pea emergence or large gaps in the seed row.	• poor germination or low vigor (seed is found and may or may not be rotted) • seed decay or seed rot (seed may not be found) • no seed found - seed decay or poor seeding patterns (seeding too fast) • plumule (shoot) has been cut below soil surface - cut worm damage • plumule (shoot) below ground is brown near seed - common root rot • plumule (shoot) cut or damaged at soil surface - wind damage
Uniform pea emergence but patches are twisted, stunted or dying.	• orange center in lower stem and plumule - fusarium wilt • possible residual herbicide damage • excess water causing root rot • high soil salinity levels
Uniform pea emergence but patches are dying although secondary buds forming.	• frost damage • soil residual herbicide damage
Poor root system but no browning.	• phosphate deficiency • extremely wet soil conditions
Nodulation not present at 5 to 6 node stage.	• inoculant problem or inoculation problem • very acid soils • high soil nitrogen
Nodulation present but green pulpy nodules.	• high soil nitrogen • extremely dry soil conditions
Pea plants are turning yellow.	• excess water causing root rot • no nitrogen fixation • herbicide residue in the soil • herbicide application damage (low water volume) • herbicide drift if in pattern near edge of field • extreme drought and nitrogen fixation stops
Extremely tall growth, long internodes.	• excess soil or fertilizer nitrogen combined with good moisture
Compressed plant growth, extremely short internodes.	• drought • herbicide injury from soil carryover • herbicide injury due to low water volumes • herbicide injury due to late application (6+ nodes)
Main plant (5 to 7 node stage) is stalled in growth – new tillers forming.	• high soil salinity • classic case of herbicide damage due to low water volumes, cocktail mixes or sprayer tank residues • herbicide injury from soil carry over
Twisting of main stem or tendrils.	• herbicide drift • herbicide injury from tank contamination
Flowers are falling off or pods not forming on upper flower nodes.	• flower blast due to heat/low moisture stress • general drought damage • downy mildew symptom
Leaves are yellow but veins are green.	• possible fertility imbalance of magnesium or manganese deficiency (not common)
Lower stems near soil surface are purple/black.	• early symptoms of ascochyta complex
Stem portion white with remaining plant green.	• classic sclerotinia stem rot
Premature lodging or excessive lodging for the variety.	• high soil residual nitrogen • mycosphaerella/ascochyta disease complex • excessive moisture
Various pods have white blotches.	• grasshopper damage • downy mildew infection • hail damage

Field pea diagnostic chart (cont.)	
Various pods have discolored or rotting ends.	• botrytis or grey mold damage
Pods are prematurely splitting open – pea seed also splitting.	• environmental, high moisture levels after a prolonged drought
A leaf or leaves on only parts of plant are yellowing.	• possible virus infection
Brown lesions with dark margins on leaves, pods and stems.	• classic symptom of ascochyta infection
White powdery coating on pods and plants.	• classic symptom of powdery mildew infection

Field Pea Harvesting

Pre-Harvest Considerations

Depending on type and variety, seeding date and seasonal moisture, field pea crops require a growing season of approximately 90 to 105 days. Pea harvesting must be considered in terms of an overall harvest system. Paying close attention to crop and equipment needs will usually result in earlier harvesting, higher quality and optimum yields. Pay particular attention to:

- equipment readiness
- pre-harvest field monitoring
- proper storage of the final product

All necessary equipment modifications should be made well before harvest time.

Desiccation or swathing can start when seed moisture content has reached approximately 25 to 30 per cent. Drydown of the sprayed crop to 16 to 18 per cent seed moisture normally takes five to seven days, depending on weather. Once the crop is combined, a short time in an aeration bin may be required if the grain is not at storable 16 per cent or if the grain is warm.

If the crop is to be straight combined, you can begin when seed moisture content has reached approximately 18 to 20 per cent, provided the straw is dry enough to feed through the combine. Aeration of straight-harvested pea is generally required to condition the grain for longer storage.

Field Monitoring

Pre-harvest field monitoring will help determine which harvest system to consider, if more than one is available, and will greatly assist in determining when to begin harvest operations. Monitoring pea fields means checking plants in numerous locations for uniformity of stages of maturity. Most fields will not be 100 per cent uniform in topography – there could be greener conditions in lower, wetter areas and further advanced plants on higher areas.

Pre-harvest monitoring – harvest uniformity

Therefore, a decision to begin harvest will hinge on a majority of the field meeting certain criteria. Do not sacrifice the quantity and quality of your crop waiting for smaller greener areas to reach the proper stage to start harvest.

The decision to start the harvest process will depend on three factors:

- crop maturity (stage of uniformity)
- seed moisture content
- presence of weed growth

Crop Maturity

- field pea plants mature from the bottom to the top – when monitoring a pea crop, look for a large majority of plants that have tan pods on the bottom, yellow to tan pods in the middle area and yellow green pods on the top
- seeds in **bottom pods** will be very firm and require some force to dent the seed coat with a fingernail
- seeds from **middle pods** will flatten somewhat with pressure between the thumb and finger, and the seed coat will dent with a little fingernail pressure
- seeds from the **uppermost pods** will be fairly soft and, with a little pressure, will split into two cotyledons

Seed Moisture Content

- seed moisture content of physiologically mature pea will decrease quickly if weather conditions are warm and dry and if humidity is low
- drought stress in the crop will also result in rapid drydown

Presence of Weed Growth

- waiting for green weed growth to drydown will jeopardize quality and yields
- swathed green weeds are unlikely to dry sufficiently in a few days, so combining will be delayed
- green weed material in a straight-cut operation will cause extra wetness in the threshing areas of the combine, resulting in moisture on the seed coat and dirt adhering to this moisture (earth tag)
- grades will be lowered because of earth tag

Pre-Harvest Questions

Before harvesting, ask yourself the following questions:

- does the value of the crop dictate whether a desiccant is used?
- what machinery is available for harvest?
- should additional resources be secured?
- how will the harvested grain be marketed: human edible, livestock feed or seed?
- how variable is the crop's maturity?
- any other variability of crop readiness in the field?
- what are the current weather patterns?

Harvest Timing and Systems

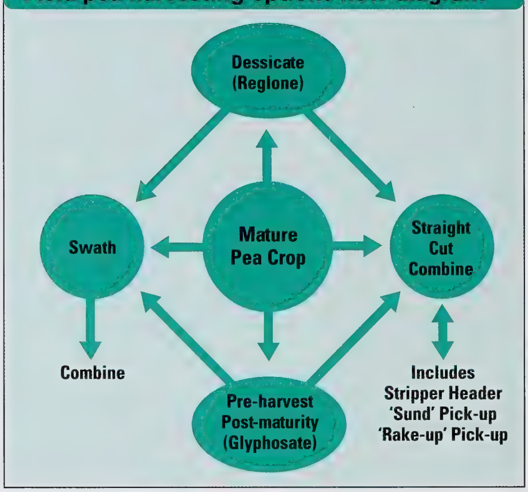
Timely harvest of a pea crop is critical:

- **harvesting too early** will result in immature seeds – this is especially important with yellow cotyledon varieties because immature yellow-green seeds will result in downgrading
- **harvesting too late** when the pods are dry and brittle may result in shatter losses and will increase the risk of poorer quality seed due to adverse weather – for green pea varieties, harvesting even several days later may result in excess bleach

The method or type of harvest to be used must be decided well before maturity advances and shattering begins. Field pea can be harvested with a number of different systems. The system used will depend on equipment availability, crop condition and weather conditions.

- the crop can be swathed as early as possible and then combined when dry
- it can be allowed to mature standing, sprayed with a desiccant if necessary and then swathed directly ahead of the combine or direct combined
- since most varieties of field pea will lodge before harvest, swathing or direct combining operations are usually best carried out at a 90 degree angle to the way the crop is lying

Field pea harvesting options flow diagram



Swathing

Swathing can be done when most of the vines and pods have turned to a yellow-tan color, and seeds are difficult to dent with a thumbnail. As much as one-third of the vines and pods may still have some lime green color left, but these plants will cure in the swath. The fully formed but immature seeds will dry without much shrinking – the overall seed moisture content will be approximately 25 per cent.

These swathing tips will aid in the best harvest conditions:

- lower areas of the field (which remain green) should be ignored when the proper swathing or straight cutting time approaches for most of the field – delayed cutting to allow these areas to advance in maturity may jeopardize quality and quantity of the remainder of the crop
- swath rolling may be necessary to protect the swath from wind damage if the swather lays a dense narrow swath. A very mature dry crop may result in a fluffy

swath, prone to wind damage (rolling drier pea swaths will result in greater seed shattering in the swath)

- lay a wide, shallow swath that will cure and dry quickly – adjust the discharge opening of the swather to as wide as possible to lay a wide swath (avoid piling the swath in bunches)
- the combine should follow closely behind the swather, if the crop is to be swathed when it is fully mature
- swathing should be done during periods of higher humidity to prevent shatter losses
- pea crops that are very short and have many pods close to the ground are usually best swathed when partially green – the pick-up reel will have more material to work with, resulting in a better swath
- a heavy, taller crop can best be handled with a narrow swather table or by taking a narrow cut (12 ft. to 15 ft.) with a wider table
- match swath size and density to the combine capacity so that a uniform feed is achieved
- all varieties of field pea have hollow, weak stems and most will lay over or lodge when heavy in pod – the best method of swathing or straight cutting a lodged pea crop is at a right angle to the direction in which the crop is lying
- swath the crop slowly – for example 3 to 4 mph (as slowly as it takes to lay an even, uniform swath)
- swathers should be equipped with a pick-up reel, preferably with stiff fingers, and with vine lifters – adjustment of the pick-up reel, backward or forward, may alleviate piling problems

Too early for swathing

Proper stage for swathing

Too late for swathing

- many types of vine lifters are available, and most allow for some adjustment to perform well on all headers – lifters should be spaced every 12 in. on the header for most pea crops but may have to be spaced as close as 6 in. for short, thin crops (for extremely short crops, lifters may have to be removed to get the cutter bar below the lowest pod)
- swather tables should be fairly narrow, so the table will follow ground contours as the crop is cut close to the soil surface – a narrow table will also produce a more shallow swath (there is usually very little stubble to keep the swath off the soil surface, so rapid drying is important)
- gauge wheels mounted on the swather table will also aid swather operations – gauge wheels help prevent the cutter bar from digging into the soil and maintain uniform cutting height with less operator fatigue
- swather tables with adjustable pitch should be adjusted to a steep pitch – this angle will help get the cutter bar closer to the ground and will allow the crop to come off the draper more evenly

Types of vine lifters

Combining immediately behind swather

Combining

Field pea can be successfully combined as soon as the seed moisture content is down to 20 per cent or less. Seed damage will increase as the crop becomes drier than 16 per cent. This damage reduces both germination and quality.

- pea vines that are damp or slightly green will greatly increase combine power requirements and may result in plugging and wrapping problems
- combining at **too high a moisture content** (over 20 per cent) will increase the amount of earth tag on the pea seed (earth tagging may also occur when combining starts too early in the morning or continues too late in the evening and when dew is present; earth tagging is also common when weeds like thistle or quack grass are present)

Rapid harvest – high combine capacity

- combining at **too low a moisture content** will cause excessive cracking and splitting losses – cracked and split seed downgrades quality when pea is destined for the seed or human consumption market
- keep the combine operating at full capacity to help reduce seed damage in the cylinder and also in the grain elevators
- combine hoppers should be unloaded at slow speeds to reduce seed damage

General recommendations for combine settings include:

- low cylinder speed
- ample concave clearance
- maximum wind velocity

Swathed Field Pea

Picking up a well-formed pea swath is generally not a problem. Combining is easiest if the width of swather cut is well-matched with combine capacity and the moisture content of the crop is between 16 and 20 per cent. These conditions require the least combine power, and good separation takes place readily.

Combining swathed field pea

- pick-up speed should be carefully matched to the combine ground speed to minimize shatter losses
- if the combine is equipped with a variable speed pick-up, the proper feeding rate of the swath is much easier to maintain
- sprocket change on the pick-up drive may be needed to reduce the pick-up speed to that suited for pea swaths

Direct Combining

Field pea can either be straight combined with a standard type cutter bar, a floating cutter bar or with a special pick-up attachment (example is Honey-Bee header).

Direct combining field pea

- if using a special pick-up, the crop should be uniformly dry to the soil surface
- a pick-up reel and lifters on the knife guards will usually be required for both standard and floating cutter bars
- flexible lifters are preferred over the more aggressive rigid lifters for straight cut headers as they reduce the amount of dirt entering the combine
- proper header height control is important to avoid picking up dirt, which will cause earth tag (earth tag is not easily removed from pea seed and will usually lower the grade of the grain)

Stripper Header

This is the newest header type for straight combining pea crops. It incorporates a flail type cylinder enclosed in a shroud and is operated at 1 in. to 2 in. above the soil surface. One advantage to the stripper header is its ability to harvest badly lodged pea crops.

Combining with a stripper header

- careful adjustment and maintenance of the stripper header is needed to offer a clean undercarriage to eliminate hang-ups of pea vine and dirt entering the combine
- some concern exists that operating the machine at very high rpms in dry pea crops will increase the damage to the seed and increase the amounts of split pea and dockage
- the stripper header width should be properly matched to the combine capacity to both increase efficiency and not overload the combine

Special Pick-Ups/Direct Combining

Another method for direct combining a pea crop is to use a special pick-up (manufactured by Sund or Rake-Up), which pulls the standing, very mature dry pea crop into the combine.

- pick-up wheels may be replaced with coulters, which cut the pea vines at the edge of the pick-up
- pea vines must be very dry because this type of pick-up works by breaking plants off at the soil surface before pulling them onto the draper – this operation leaves most of the green weed material standing in the field, and it prevents dirt from entering the combine
- special pick-ups may not work well in short or thin crops – they perform best on longer pea vines that have fully matured and have been exposed to some rain, as the stems at the soil surface become weak after a rainy period

This type of harvest method is not a feasible option for green pea crops for human consumption markets. Green pea usually bleaches too much by the time the crop is ready for this type of equipment.

Desiccation

Desiccation (with Reglone Pro®) is warranted for seed production for green pea crops, when crop maturity is uneven or when green weed growth is a problem. But remember, **a desiccant will not assist in maturing immature seed**.

- apply as the crop is approaching physiological maturity – the application can be made when the bottom and mid-area pods have turned tan to yellow color, and top pods are pitted and starting to turn yellow
- a desiccant is a contact herbicide, so green material is killed quickly and drydown begins within a very short time – compared to natural drydown, faster (and more even) drydown can be achieved late in the season when days are shorter and generally cooler

- apply the desiccant at the same time as the proper swathing stage, wait approximately five to seven days, then straight combine or swath and follow immediately with the combine
- the use of a desiccant will usually eliminate the need for swathing, thus avoiding potential problems with wind blown swaths, rain soaked swaths and pick-up losses
- spray only as many acres at one time as can be combined in two or three days after drydown – if the entire crop will take more than two or three days to combine, stagger the desiccant application so that not all the crop is ready at the same time
- use proper rates, high water volume and spray at the correct crop stage

Post Maturity Pre-Harvest Aids (Glyphosate)

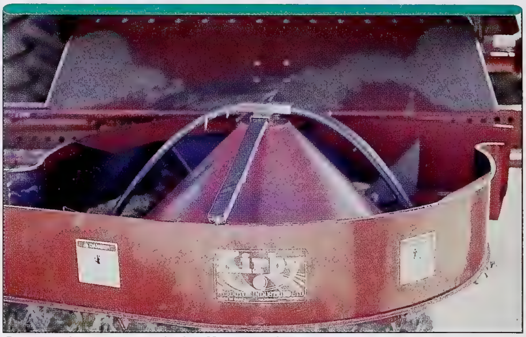
Pre-harvest treatment involves spraying the field with ground equipment when pea seed moisture content is 25-30 per cent or lower.

- the crop and in-crop weeds must have enough green material remaining at application time for the herbicide to be effective
- glyphosate, a systemic herbicide, will kill and drydown all green growth in approximately 14 to 21 days and will allow for a straight cut operation or swathing and combining immediately
- this herbicide is not registered for pea crops used for seed purposes

Pea Straw Management

One of the benefits from growing a pea crop is the positive effect of pea residue in the soil. Improved soil structure, tilth and recycled nitrogen for succeeding crops are all benefits of pea straw incorporation. In fact, most of the nitrogen returned to the soil after growing a pea crop comes from the straw. Because of these benefits, it is recommended that pea straw remain on the field and not be baled off for feed purposes.


Pea straw ready for incorporation


Straw chopper and chaff spreader

Be aware of the following:

- dry pea straw breaks up and pulverizes quite readily when combined
- straw that is slightly green or tough will remain almost whole going through the combine
- a good straw chopper and chaff spreader will cut and spread the straw and chaff sufficiently so that tillage or direct seeding is not a problem
- tough straw will wrap around the chopper drum if the straw chopper knives are dull and worn

Pea Harvest Video

For a video on pea harvesting, *Field Pea Harvesting: From Vine to Bin* is available from the Alberta Pulse Growers Commission, 4301 - 50 Street, Leduc, Alberta, T9E 7H3.

Post-Harvest Considerations

Field Pea Straw

Western Canadian research into the nutritive levels and value of field pea straw is limited, but it is believed that field pea straw has considerable nutrient value when used as an alternative feed source and as a nutrient when returned to the soil.

Value as a Feed Source

Results from a three-year study on 469 field pea straw samples from various locations in south central Alberta show large variability in nutritive value between years and sites. This variability may be a reflection of soil

fertility, moisture and environmental (growing) conditions (see Tables 32 and 34).

Table 32. Mean values of selected constituents of field pea straw (1995-97)

Year	Protein %	ADF[1] %	NDF[2] %	Calcium %	Phosphorus %
1995	12.5	50.46	63.67	1.53	0.16
1996	4.72	53.13	67.19	1.68	0.04
1997	6.83	47.58	59.88	1.76	0.076
All years	7.56	50.1	63.19	1.68	0.087

All values are on a Dry Matter Basis
[1]Acid Detergent Fiber - measure of digestibility
[2]Neutral Detergent Fiber - measure of digestibility
Olson and APGC-Zone 2, 1998

Overall quality is usually better than cereal straw (see Table 33). Field pea straw can be significantly higher in protein, but high fibre levels limit digestibility and expected feed intake.

Table 33. Ten-Year average of selected Alberta feed straws(1984-1994)

Straw	Protein %	ADF %	Calcium %	Phosphorus %
Barley	5.4	44.4	0.43	0.09
Oats	4.8	44	0.33	0.1
Wheat	4.3	47.1	0.31	0.07
Fescue	5	40.9	0.45	0.1

All values are on a Dry Matter Basis, AAFRD 1995

- field pea straw is primarily useful for beef cattle rations where high quality roughage is not as important as for other classes of livestock – when pea straw is fed with higher quality roughage and/or grain, it can produce a very cost-effective ration (the higher protein levels generally make pea straw a better match with grain than cereal straw)
- palatability studies (how well an animal will consume the feed) with field pea straw have not been conducted – anecdotal evidence with beef cattle suggest a wide range in field pea straw palatability (cattle devouring the feedstuff versus complete rejection)
- processing the straw (such as grinding or chopping it with machines like mix mills or hay busters) and mixing the straw with other feeds may help with palatability
- farmers thinking of using field pea straw in rations should have their feed tested
- note that variability between varieties was less dramatic than between sites and years (see Tables 32, 34 and 35)

Table 34. Mean values of selected constituents of field pea straw at various locations in Alberta (1995-97)

Location	Protein %	ADF[1] %	NDF[2] %	Calcium %	Phosphorus %
Carstairs	9.73	55.48	70.97	1.35	0.118
Crossfield	6.96	57.51	71.78	1.56	0.082
Didsbury	14.9	46.32	58.28	1.59	0.18
Drumheller	5.9	43.49	55.17	1.9	0.052
Linden	7.55	52.97	65.95	1.24	0.095
Three Hills	5.89	51.4	63.07	1.62	0.062
All sites	7.56	50.1	63.19	1.68	0.08

All values are on a Dry Matter Basis
Olson and APGC-Zone 2, 1998

Table 35. Mean values of selected constituents of field pea straw of four commonly grown varieties in Alberta (1995-97)

Variety	Protein %	ADF[1] %	NDF[2] %	Calcium %	Phosphorus %
Carneval	7	53.33	66.12	1.46	0.077
Grande	7.69	51.9	64.48	1.43	0.086
Majoret	7.16	52.69	65.94	1.56	0.076
Montana	7.8	46.36	59.42	1.98	0.09
All varieties	7.42	51.1	59.42	1.6	0.082

All values are on a Dry Matter Basis
Olson and APGC-Zone 2, 1998

Nutrient Value of Straw Returned to Soil

It is questionable whether benefits derived from removing straw from the field through baling are greater than incorporating it into the soil. Field pea straw contains nutrients, which once broken down by the soil microflora, can be made available to the following year's crops. However, the total value of nutrients varies considerably depending on total pounds per acre of straw produced, shown in Table 36.

Table 36. Nutrient value of pea straw produced

lb./acre of pea straw removed	N lb./ac.	N=$.28	P lb./ac.	P=$.30	K lb./ac.	K=$.14	S lb./ac.	S=$.22	Total value
1000	12	$3.35	2	$0.60	17	$2.38	1.3	$ .29	$ 6.62
1500	18	$5.05	3	$0.90	25	$3.50	2	$ .44	$ 9.89
2000	24	$6.70	4	$1.20	33	$4.62	2.6	$ .57	$ 13.09
2500	30	$8.40	5	$1.50	42	$5.88	3.3	$ .73	$ 16.51

Olson and APGC-Zone 2,1998
Notes: Nitrogen (N), Phosphorous (P), Potassium (K) and Sulphur (S) are actual in lb./ac. Nutrients are $/ac. Calculated using 1995-1997 average nutrient levels for N = 7.56%, P = 0.087%, K=1.38% and S =0.133%

When assessing the benefits of baling versus incorporating, the cost of baling straw ($7.25 to $10.25/tonne) and hauling it ($3 to $10.25/tonne) must be taken into consideration (source *Alberta Machinery Guide 1998*).

Given these factors (taking baling and hauling to the customer's yard into account) and the value of the nutrient contained in the straw, a break-even return of $22.12 to $32.37/tonne is required.

The decision to work straw back into the soil or bale and feed it is entirely up to each individual operation.

It's important to recognize field pea straw's worth and not under-value it. Farmers thinking of removing field pea straw should test it for protein, phosphorus, potassium and sulfur to determine the nutrient content.

Table 37 will help determine the worth of pea straw. A feed analysis of a representative sample of pea straw for protein, phosphorus, potassium and sulphur is needed to do the calculations.

Table 37. Calculating pea straw nutrient level

		Your Number
STEP 1. Nitrogen	1) lb./ac. of straw X % protein of straw (as fed) 2) lbs. protein/acre divide by 6.25 (Kjedahl) 3) multiply actual lb./ac. removed by cost of nitrogen per pound (not product)	
STEP 2. Phosphorus	1) lb./ac. of straw X % phosphorus (as fed) 2) fertilizer sold as P_2O_5 61/141 = .43 molecule 3) actual phosphorus lb./ac. divide by .43 4) lb./ac. of P_2O_5 X cost of phosphorus per pound (not product)	
STEP 3. Potassium	1) lb./ac. of straw X % potassium (as fed) 2) fertilizer sold as K_2O 78/94 = .82 molecule 3) potassium lb./ac. divide by .82 4) lb./ac. of K_2O X cost of potassium per pound	
STEP 4. Sulphur	1) lb./ac. of straw % sulphur (as fed) 2) actual sulphur lb./ac. X cost of sulphur per pound (not product)	

The Dry Bean Plant

Dry Bean Description

Dry bean (*Phaseolus vulgaris*) cultivated types are herbaceous annuals, determinate or indeterminate in growth habit, which bear flowers in axillary and terminal racemes. Flowers are normally self fertilized, developing into a straight or slightly curved pod. Seeds may be round, elliptical, somewhat flattened, or rounded-elongated in shape and have a rich assortment of coat colors and patterns. Seeds of varieties produced in Alberta range in size from 170-400 gm per 1000 seeds.

Dry bean is a vining herbaceous annual

Figure 23. Seedling development of dry bean

Podding

- determinate types have a central main stem with five to nine nodes and from two or more branches that arise from the more basal nodes
- indeterminate types have a main stem with 12 to 15 nodes, or even more in climbing vine types

Seedling stage

- germination is epigeal and requires approximately 7 days at a soil temperature of 16 degrees C
- days-to-flower varies with variety, temperature and photo period and can take up to 50 days
- physiological maturity will occur approximately 105-115 days from planting in southern Alberta
- Figure 23 illustrates seedling development of dry bean

Adaptation

Temperature

- dry bean requires a warm growing season but is not adversely affected by high temperatures as long as soil moisture is adequate
- the crop can tolerate temperatures as high as 35 degrees C – temperatures higher than this may cause flower drop, especially if high temperatures persist for an extended time
- daytime temperatures between 20 and 32 degrees C are ideal for dry bean production – temperatures below 10 degrees C will limit plant growth and development – below 8 degrees C at flowering will cause substantial flower abortion

- grow dry bean crops in areas with a long growing season that is warm enough to allow for proper plant development – dry bean is very sensitive to frost or prolonged exposure to near-freezing temperatures and must reach physiological maturity before the first killing frost of the season (dry bean can be grown in areas of southern Alberta that receive 1900 corn heat units or more during the growing season)
- cool, damp weather during August and early September will delay maturity of the plant – this kind of weather (especially in fringe areas) will delay maturity and make the crop susceptible to first frost, with even 1 degree of frost damaging the plant

Soil

- dry bean is adapted to a wide range of soil types – soils with good tilth, reasonable fertility and good drainage will promote good germination and uniform plant emergence
- the crop will perform well in medium-textured soil such as light loams, sandy loams or silt loams – in fact, these soil textures are preferred because they offer good water infiltration, good water-holding capacity, higher organic matter and good tilth, which prevents soil crusting
- other soil textures in Brown and Dark Brown soil zones can also produce a good dry bean crop if properly fertilized and managed
- dry bean is very sensitive to poor drainage conditions, so avoid using fields with extensive low-lying areas that have poor drainage – growth will be affected if the crop stands in water for 24 hours


Low-lying area

- low-lying areas with salinity readings of more than 2.0 millimhos/cm should be avoided – dry bean is sensitive to salinity, which will affect germination, emergence and plant growth resulting in reduced yields (plants affected by salinity become yellow or stunted, and leaf edges brown and die)
- dry bean can tolerate a wide range of soil pH, from 6.0 to 8.3 (as pH approaches outer extremes of this range, nutrient deficiencies may occur)
- dryland production is not recommended for southern Alberta, as yields will be highly variable – the crop depends on sufficient rainfall, and dry bean yields for crops grown under dryland conditions will be substantially lower than crops grown under irrigation

Market Types and Uses

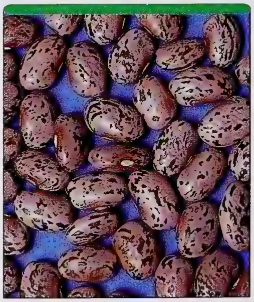
Alberta dry bean is sold in dry packaged form for human consumption. Bean is an excellent source of protein (22-23 per cent), is low in fat and is a good source of thiamine and niacin. Bean is low in riboflavin and vitamins A, C and B_{12}. Dry bean, like most other annual legumes, is low in amino acids methionine, tryptophan and cystine.

Several commercial types of dry bean are grown in Alberta, but production is greatly influenced by adaptability to a particular region and market demand. The majority of commercial production falls into five types: Pinto, Pink, Red Mexican, Great Northern and Black (Navy bean is also produced, but on a relatively small acreage).

Dry bean types can also be grouped according to plant growth habit. The types grown in Alberta are either determinate bush or indeterminate vining. The most widely grown in Alberta are indeterminate vining types.

Pinto

- in Alberta, pinto accounts for approximately 38 per cent of the acreage
- pinto is easier to produce than other types as seeds are not as prone to cracking, and seeds germinate and emerge rapidly
- seedlings tend to be strong and vigorous, and seed quality is not affected as much by adverse weather conditions (compared to other types)


Pinto

Pink


Pink

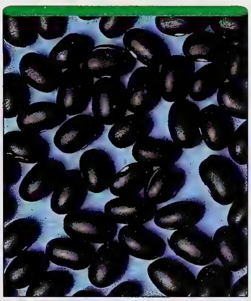
- approximately 14 per cent of Alberta's dry bean production
- generally higher yielding than other types of bean
- has smallest seed size of the colored types
- varieties grown in Alberta usually have a somewhat bushy and relatively erect plant habit

Red Mexican

- accounts for approximately 40 per cent of Alberta's production
- also called "Small Red"
- an indeterminate and semi-vining type, more upright than pinto bean

Great Northern

- accounts for approximately 7 per cent of Alberta's production
- also called "Large White"
- one of the oldest dry bean types grown in western North America
- newer varieties are erect and indeterminate


Black

Black and Navy

- account for the balance of Alberta's production

Grading Dry Bean

Classes and Varieties

- there are numerous classes of dry bean, and the class of bean forms part of the grade name (for example, Bean, No. 1 Canada Pinto)
- dry bean is graded without reference to variety

Determination of Dockage

- this procedure is performed on uncleaned dry bean – No. 8, 9 or 11 slotted sieve cleaning equipment is used, depending on seed size

Procedure

- dockage is determined on two or more representative 250 gram samples
- the sample is sieved over the appropriate slotted hand sieve and hand-picked to remove all coarse foreign vegetable matter such as pods, stems, straw and thistle tops, but not mineral matter, ergot, sclerotia, weed seeds or other grains

Composition of Dockage

- all material removed by sieving or hand-picking as defined above is included in dockage
- in samples eligible for off-grades, dockage consists of the material described above – however, dockage is not applied against samples eligible for the following grades:
  - Bean, Sample Canada (class), Account Fire Burnt
  - Bean, Sample Salvage

Reporting Dockage Percentages

- dockage is reported to the nearest 0.5 per cent

Sample Grades

- sample-grade bean is graded with reference to "Canada," (for example **Bean, Sample Canada (class), Account Heated**)

Grading Factors

- **Contrasting classes**: bean of another class that is of a contrasting color, size and/or shape to the predominant bean in a sample is considered to be a contrasting class – samples containing contrasting classes in excess of the tolerance for the lowest numerical grade are graded **Bean, Sample Canada (class), Account Contrasting Classes**
- **Other classes that blend**: sound bean of other classes that is similar in color, size and shape to the predominant bean in a sample is considered to be of a blending class – samples containing bean of other classes that blend in excess of the tolerance for the lowest numerical grade is graded **Bean, Sample Canada (classes), Account Other Classes That Blend**
- **Foreign material**: including any material other than bean or split bean, such as stones, shale or similar material, ergot and sclerotia not removed in cleaning – bean containing foreign material in excess of the tolerance for the lowest numerical grade are graded **Bean, Sample Canada (class), Account Admixture**
- **Earth pellets (soft)**: including soft fertilizer pellets and any non-toxic material of similar consistency – earth pellets in the cleaned portion of unprocessed

bean are hand-picked and assessed as dockage; in processed bean, earth pellets that do not crumble under light pressure are treated as stones

- **Stones (in bean)**: hard shale, hard earth pellets, hard fertilizer pellets and other non-toxic materials of similar consistency are considered stones – samples of beans whose content of stones is over 0.5 per cent by weight, and up to and including 2.5 per cent by weight, are graded **Bean, Rejected (grade) (class), Account Stones**; samples of bean whose content of stones exceeds 2.5 per cent by weight are graded **Bean, Sample Salvage**
- **Stones (in pea bean)**: hard shale, hard earth pellets, hard fertilizer pellets and other non-toxic materials of similar consistency are considered stones – samples of pea bean whose content of stones is over 0.2 per cent by weight, and up to and including 2.5 per cent by weight, are graded **Pea Bean, Rejected (grade) (class), Account Stones**; samples of pea bean whose content of stones exceeds 2.5 per cent by weight are graded **Pea Bean, Sample Salvage**
- **Damage**: including whole, split, or broken bean that is sprouted, very immature, perforated, distinctly deteriorated or discolored by weather or disease, or that is otherwise damaged in a way that seriously affects appearance or quality
- **Splits**: including split bean, broken pieces of bean less than three-quarters of whole kernels, halves loosely held together by cracked seed coats, and bean with cracked cotyledons (such as may result from artificial drying) (splits do not include any bean otherwise damaged)
- **Magnesium spot**: refers to a black spot penetrating the cotyledon, most commonly found in cranberry bean – affected bean is considered damaged
- **Heating in pea bean**: indicated by a dull seed coat varying from cream to mahogany color (the color is more intense in the hilum area) (when viewed in cross-section, the cotyledons are considered damaged rather than heated)
- **Heating in red kidney bean**: indicated by a dull seed coat, dark red to black color – bean suspected as damaged by heat are split to determine the degree and severity of damage
- **Rotted bean**: kernels or pieces of kernels that are visibly in advanced stages of decomposition and feel spongy under pressure are considered rotted – rotted kernels are considered in combination with heated kernels
- **Mold**: characterized by the presence of dark blue exterior molds that develop in machine-damaged crevices and yellow to black interior molds developed in the concave center area common to light and dark kidney bean – bean containing more than 1.0 per cent by weight of heated, rotted and/or moldy bean, or having a heated or musty odor are graded **Bean,**

Table 38. Grades of bean of classes other than Cranberry, Blackeye, Yelloweye or Pea Bean (Canada)

Grade Name	Standard of Quality	Maximum limits of Foreign Material					
		Stones Shale or Similar Material	Total Foreign Material	Contrasting Classes of Bean	Damage, Foreign Material and Contrasting Classes of Bean	Total Damage Including Splits, Foreign Material and Contrasting Class of Bean	Other Classes of Bean that Blend
Extra No. 1 Canada	Uniform in size, of good natural color	Free	About 0.05%	1.0%	1.0%	1.0%	1.0%
No. 1 Canada	Reasonably good color	About 0.05%	About 0.1%	1.5%	1.5%	2.0%	3.0%
No. 2 Canada	Reasonably good color	About 0.1%	About 0.2%	3.0%	3.0%	4.0%	5.0%
No. 3 Canada	Fairly good color	About 0.2%	About 0.5%	5.0%	5.0%	6.0%	10.0%
No. 4 Canada	Off color	About 0.5%	1.0%	8.5%	8.5%	10.0%	15.0%

The color may be added to and become part of the grade name.
Table – Canadian Grain Commission – August 1, 1998

Sample Canada (class), Account Heated or Account Moldy Kernels; samples with a fire burnt odor are graded **Bean, Sample Canada (class), Account Fire Burnt**

Heated, rotted and moldy bean will be combined with other types of damage and included in the specification for total damage including splits, foreign material and contrasting classes.

- **Odor**: samples with any type of unnatural or objectionable odor other than that of heated or fire burnt kernels are graded according to the basic quality of the sample, the type and degree of odor, and the presence of visible residue causing the odor; samples having a distinct odor not associated with the quality of the grain are graded **Bean, Sample Canada (class), Account Odor**; samples having a heated odor are graded **Bean, Sample Canada (class), Account Heated**; samples having a fire burnt odor are graded **Bean, Sample Canada (class), Account Fire Burnt**
- **Cracked seed coats**: considered sound if the halves are firmly held together and the bean is otherwise undamaged
- **Adhered soil**: unprocessed pea bean densely covered with adhered soil (often referred to as mud balls) that will ultimately be removed in processing are assessed as dockage; in processed samples, pea bean is considered damaged
- **Color**: determined on the basis of the cleaned sample, after the removal of splits and damaged bean:
  - good natural color: slightly dull, slightly immature or very lightly earth-tagged
  - reasonably good color: moderately immature, lightly earth-tagged or lightly stained
  - fairly good color: moderately earth-tagged or stained
  - off-color: cannot be considered of fairly good color, but is not severely earth-tagged, immature or severely stained

Dry Bean Varieties


Dry bean types

Southern Alberta is the largest, northern commercial bean growing area in North America. As the growing season is short and relatively cool, the number of suitable varieties for this area is limited.

Up to the early 1990s, only American varieties (particularly from Idaho and Washington) were available to Alberta producers. Since then, a few suitable Canadian varieties have been released through the Crop Development Center, University of Saskatchewan and Agriculture and Agri-Food Canada. More suitable varieties will be available from these sources in the future.

Othello dry bean grown in Alberta

Viva dry bean grown in Alberta

Table 39 outlines varieties presently being tested in the Alberta Regional Variety Test Program for Dry Bean. The test includes both wide row and narrow row evaluation, with data from 1994-1998.

For further reference, consult Agdex 140/32-1 Varieties of Special Crops in Alberta.

Table 39. Dry bean regional variety test data

		Yield (% of check) 1994-1998				
Variety	**Type**	**Wide row**	**Narrow row**	**Days to* maturity (+/- check)**	**Plant height* (cm)**	**Seed weight* (g/1000)**
AC Harblack	black	-	147	+7.3	38.0	173
Blackjack	black	58	113	+10.5	45.4	178
CDC Expresso	black	59	100	+5.1	33.4	212
CDC Nighthawk	black	-	94	+4.5	41.2	176
UI 906	black	81	119	+4.3	37.0	159
Taylor	cranberry	49	-	+2.9	36.2	446
92074	great northern	-	120	+2.7	39.3	359
93128 (Crocus)	great northern	105	92	-1.0	36.0	391
Beryl	great northern	102	-	+3.3	45.0	287
CDC Nordic	great northern	86	113	+1.8	33.4	351
GN 1140	great northern	108	-	+4.3	48.0	322
Red Kloud	large red kidney	65	-	+7.1	37.6	482
AC Mariner	navy	53	88	+9.6	38.1	192
AC Skipper	navy	58	101	+4.5	37.2	212
CDC Whistler	navy	-	134	+10.6	41.7	159
ISB 565	navy	-	134	+7	39.4	169
Seaside	navy	-	116	+5.6	45.1	187
Upland	navy	73	117	+6.5	44.1	182
93318	pink	93	98	-0.7	34.0	250
AC Alberta Pink	pink	111	107	-2.0	33.5	294
Viva	pink	102	-	+1.9	40.4	260
92235 (Pinnacle)	pinto	-	151	+1.7	45.0	365
92802 (Pinyata)	pinto	93	124	-1.5	41.2	356
92708 (Pintium)	pinto	95	118	-7.3	38.5	378
CDC Camino	pinto	88	146	+0.3	42.2	362
Earliray	pinto	72	-	-4.3	29.6	376
Fargo	pinto	91	113	-2.7	46.0	363
Fieasta	pinto	92	-	+5.6	52.4	382
Othello	pinto	100	100	0.0	45.8	360
Pinray	pinto	72	120	+10.6	43.5	371
Topaz	pinto	90	126	+1.8	52.0	344
AC Earlired	red mexican	108	108	-5.3	36.0	328
Carmine	red mexican	102	-	+0.6	43.1	303
NW 63	red mexican	93	-	+4.6	46.2	320
Prim	yellow	-	102	+3.8	36.0	244

Check variety - OTHELLO, yield wide row = 2916 kg/ha.; yield narrow row = 1969 kg/ha.; days to maturity = 101
* values are means of wide row tests only, narrow row test mean values were only used for varieties not included in the wide row test

Pre-Seeding and Seeding Management

Seedbed Preparation

Land must be properly prepared to provide seed with the best environment for rapid germination and emergence, allow roots to grow quickly and absorb nutrients and provide the conditions necessary for good weed control and proper irrigation.

Dry bean requires warm, moist soil conditions for germination and emergence. The soil must be prepared so it warms rapidly, but still retains as much moisture as possible. Fall plowing is preferred because it conserves more moisture than spring plowing. Freezing and thawing during winter tends to reduce soil clods.

Tips to enhance seedbed preparation:

- land should be moderately firm, level and free of clods and trash
- land needs adequate moisture in the seeding zone
- soils, especially heavy clay types, must be worked at the right moisture to avoid producing a lumpy seedbed and soil compaction
- avoid excessive tillage – it's not only costly, but can cause compaction that interferes with water drainage and root penetration, also has a tendency to dry out the seedbed
- compacted wet soils tend to warm slowly and cause delays in germination and emergence

Seed Quality


High quality and color

- dry bean is very sensitive to a number of seed-borne diseases – it is critical to plant disease-free seed
- purchasing seed from areas isolated from commercial production will ensure seed is disease-free
- ensure seed lots contain sound, whole seed and that seeds have few hairline cracks

Dry Bean Inoculation

- dry bean has a relatively poor ability to fix nitrogen compared to some other species in the annual legume family (it can fix about 30-40 per cent of its own nitrogen needs)
- inoculate bean seed when planting in a virgin field
- dry bean is normally grown on irrigated fields where residual N levels are quite high – if residual N level in the top foot of soil exceeds 40-50 lb./ac., nitrogen fixation will be inhibited and ineffective (often no pink/red nodules will be observed on the bean root under these conditions)
- dry bean seed is often treated with Captan®; this fungicide can harm dry bean *rhizobium* – only apply inoculant to the seed immediately before seeding, or apply in granular form in the seed row
- three types of dry bean inoculant are available: Peat (including Self Stick Peat), Liquid and Granular

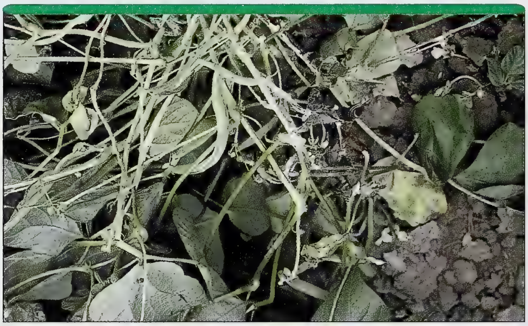
For more information, refer to the section in this manual on Inoculation of Pulse Crops.

Seed Handling and Sowing

- bean seed should be placed into warm, moist soil to a depth of 1 to 2.5 inches (2.5 to 6 cm)
- if soil moisture is too low to initiate germination of this large-seeded crop, an irrigation prior to seeding followed by a light tillage operation is strongly recommended
- irrigating after seeding often reduces soil temperature below that required for bean germination – this low temperature may increase both the incidence of fungal diseases of the root system and the chance of damage to the seed (and germinating seedling) by insects
- bean seed is very fragile – take care to ensure the seed coat is not cracked during handling or seeding, as bean seed with cracked seed coats will not germinate, resulting in a decreased plant population
- precision planters provide the most uniform seed drop per foot of row and minimize the amount of seed required, thus reducing the cost of seed per acre and minimizing inter-plant competition
- vacuum or air precision planters provide the most accurate seed drop (but plate and peanut bottom planters do an adequate job)
- regular drills or air seeders do not provide accurate seed drop – use great care with these seeding implements to minimize seed damage
- dry bean is generally grown as a row crop – space rows so that cultivation and harvesting equipment can be used efficiently (row spacings vary from 22 to 30 inches (56-76 cm), with 24 inches (61 cm) being most common)

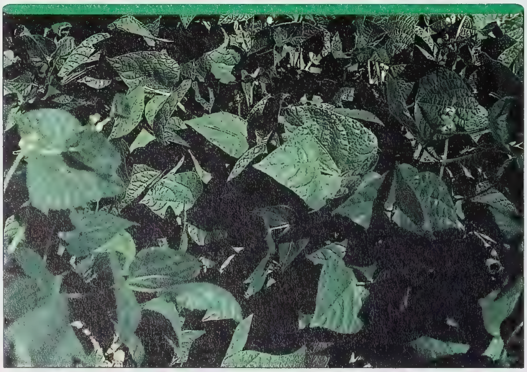
Dry bean is generally seeded as a row crop

- narrow row crops should produce higher yields, but high disease pressure (particularly white mold) and higher harvest losses result in lower yields compared to wide row crops



Narrow row planting promotes high disease levels

- solid seeded bean is normally planted in 7 inch (17.5 cm) rows with either a conventional grain drill or air seeder – this type of seeding system requires much higher seeding rates, and care is needed to obtain a uniform seeding depth and to minimize seed damage



Solid-seeded dry bean

Crop establishment

- plant bean rows in the direction of the prevailing winds to maintain a drier soil surface, which will help supress white mold

Seeding Date

- bean plants are not frost tolerant, so seeding should not begin until the likelihood of frost has passed (in southern Alberta, this normally results in a seeding date between May 20 and May 25)
- it's also important that the crop be completely mature before the first fall frost, or crop quality will suffer
- the latest date to plant dry bean to qualify for Agriculture Financial Services Corporation (AFSC) Crop Insurance is June 10
- ideal soil temperature for germination of dry bean is 18 degrees C – seeding when soil temperatures are below 12 degrees C will result in slower emergence and weaker plants
- cool, moist soil provides an ideal environment for insects and disease, resulting in damage to young seedlings

Flood irrigation (row crop)

Row crop

Seeding Rate for Row Crop Dry Bean

- seeding rate should be targeted between 95-100,000 plants per acre
- the number of seeds per pound will vary between varieties and types (as well as from year to year), so do a seed count with all lots (see Table 40 for proper calibration of planters)

Seed Treatment

Most bean seed purchased in southern Alberta is pre-treated with a fungicide. It is also beneficial for the grower to treat the seed with an insecticide as well to protect against two insects that cause damage to bean seed and seedlings: wireworm and corn root maggot.

Table 40. Planter calibration for dry bean

Spacing of Seed on Varied Row Spacing					
Plants/Ac.	22 inch	24 inch	26 inch	28 inch	30 inch
90,000	3.2	2.9	2.7	2.5	2.3
93,000	3.1	2.8	2.5	2.4	2.2
96,000	3.0	2.7	2.5	2.3	2.2
99,000	2.9	2.6	2.4	2.3	2.1
102,000	2.8	2.6	2.4	2.2	2.0
105,000	2.7	2.5	2.3	2.1	2.0
108,000	2.6	2.4	2.2	2.1	1.9

Row Spacing	Distance Traveled = 1/1000 of an acre		
22 in.	23.76 feet	eg.	a) Use corresponding row spacing
24 in.	22.44 feet		b) Travel the required distance
26 in.	20.12 feet		c) Count number of seeds dropped
28 in.	18.66 feet		d) Seeds X 1,000 = Plant pop./acre
30 in.	17.42 feet		

Seeding rate for solid seeded bean should be targeted at 175,000 - 190,000 plants per acre

Fertility Requirements

Dry bean requires balanced fertility for optimum yield. The crop will respond to added fertilizer nutrients when soil test levels are low to medium. It is always best to soil test as an aid in developing a sound fertilizer management program.

Nitrogen (N)

- nitrogen is needed for optimum yields of irrigated bean
- dry bean is a legume capable of nitrogen fixation – when the seed is inoculated with the correct rhizobium bacteria, up to 40 per cent of total nitrogen in the plant may come from N fixation
- on irrigated land, N fertilizer is recommended if soil test N is less than 40 lb./ac. in the 0 to 24 inch depth (application of 20 to 40 lb. of N/ac. is suggested)

Phosphorus (P)

- phosphorus is a nutrient required in relatively large amounts
- a soil test is recommended to determine optimum phosphate fertilizer rates – Table 41 can be used as a guide in interpreting your soil analysis and deciding how much phosphate fertilizer is required
- phosphate fertilizer cannot be safely applied with the seed, so apply either by banding prior to seeding or side band at planting time

Table 41. Phosphorous fertilizer recommendations for irrigated dry bean

Soil Test Level, P (lb./ac.) (0-6 inch depth)	P_2O_5 Recommendations (lb./ac.)
>80	0
60-80	20
50-60	30
40-50	40
30-40	45
20-30	50
10-20	55
0-10	60

Potassium (K)

- levels of potassium in soil are usually adequate in most bean growing areas, so potassium fertilizer is not normally required
- however, if soil test potassium levels are less than 200 lb./ac., then follow the analysis report recommendation for potassium

Sulphur (S)

- sulphur is required for optimum yield, but is normally not limited in most irrigated soil as irrigation water contains substantial amounts of sulfate-sulfur (amounts in the water vary over time) – approximately 30 lb./ac. of sulfate/sulfur is added to the soil with 12 inches of irrigation water
- test soil to a depth of 24 inches to determine if sulphur fertilizer is required – if analysis levels are less than 20 lb./ac., follow recommendations of the analysis report
- general sulphur fertilizer recommendations are shown in Table 42

Table 42. Sulphur fertilizer recommendations for irrigated dry bean

Soil Test Level, SO_4S (lb./ac.) 0-24 inch depth	Sulphur Recommendations, (lb./ac.)
> 20	0
20	10
15	15
10	20
5	25
0	30

Micronutrients

- dry bean requires a supply of all the essential micronutrients: namely boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zc)
- zinc deficiency in bean plants may occur if soil pH is higher than 7.5, if soil has had high phosphate fertilizer or manure application, or if spring and early summer weather is cool and damp
- zinc deficiencies can be corrected with a pre-plant application of banded granular zinc sulfate at a rate of 2-5 lb./ac. – a foliar application of 0.5 per cent zinc sulfate should be applied if deficiency symptoms appear after emergence
- zinc deficiency is most evident following sugar beets in the rotation

Pest Management

Weed Control

- dry bean is not competitive, and severe yield loss will occur even from low weed pressure
- the most important rule of weed management for dry bean is to plant into a clean field
- pre- and post-emergent herbicides for annual weed control are limited, and effective perennial weed control herbicides are not available
- ensure that bean fields are free of perennial weeds such as Canada thistle, perennial sow thistle and quackgrass
- know which annual weeds are present, and use the field only if these weeds can be controlled
- row cropping allows for in-crop tillage to control weeds between the rows – till during warm days when the crop is slightly wilted and plants less likely to be damaged (don't till when the foliage is wet as diseases can be easily spread under these conditions)
- row cropping also allows for band spraying, which controls weeds within the row and reduces herbicides costs
- pre-emergent herbicides registered for dry bean production are Edge®, trifluralin products and Eptam®
- post-emergent herbicides registered for dry bean production are Basagran®, Pursuit® (pinto, pink and red types only), plus Poast® and Hoegrass 284® for grassy weed control


Herbicide damage

Diseases

Dry bean is very susceptible to a number of diseases and few chemical control measures are available – it's important to use an integrated management program in dry bean production:

Use proper rotations: when yield loss occurs, use extended rotations of four years with non-susceptible crops, and avoid planting adjacent to last year's bean field because many diseases are wind-borne and very mobile (shorter rotations are acceptable as long as diseases are not a problem)

Use certified seed: planting certified seed produced in arid regions is an effective technique for controlling bacterial blight

Use care when handling seed: mechanically damaged seed is prone to fungal diseases during germination, and young seedlings are less vigorous and more susceptible to fungal diseases – baldhead is also a symptom of mechanically damaged seed

The following are dry bean diseases of economic importance in Alberta:

Root Rot and Seedling Blight: *(Fusarium solani, Rhizoctonia solani* and *Pythium spp.)*


Root rot

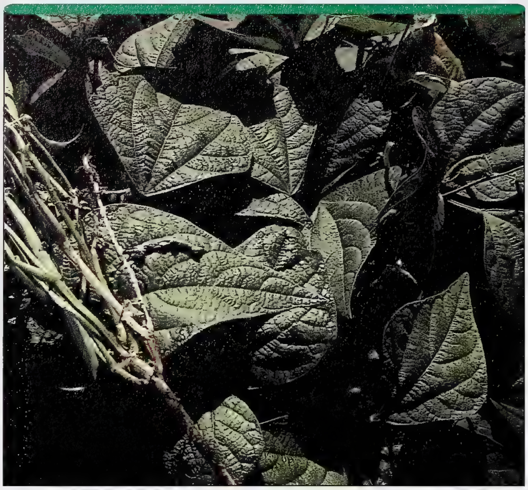
- root rot and seedling blight are common diseases of dry bean
- failure of the plants to emerge from the soil indicates seed decay or seedling damping off
- young plants may wilt and die after emergence or remain stunted and yellow (seedling blight)
- red to dark brown rotted areas appear on the taproot at or below the soil line – on larger plants, the disease often appears as a rusty brown discoloration of the tap root (root rot phase)
- as the disease progresses, the discolored area spreads until the entire taproot and lower stem are reddish brown and decayed, and secondary roots are usually decayed as well
- above-ground symptoms may not occur unless the degree of root rot is moderate to severe – then, there is likely to be stunting of the plants, yellowing of the foliage, wilting, some premature defoliation and a failure to produce normal, full pods


Root rot

- the causal fungi are all soil-borne, and plants may be attacked at any stage from seed through maturity (however, infection usually occurs early in the season and symptoms become progressively more pronounced)
- fields that have grown dry bean for several years are likely to be the most severely affected by root rot and seedling blight diseases – follow a crop rotation with cereals, alfalfa, sugar beet or corn that includes bean only once every five years
- choose fields that have good tilth and no compaction problems, so plants can form hardy roots, and moisture can move freely through the soil

White Mold *(Sclerotinia sclerotiorum)*

- white mold occurs in all dry bean growing areas of western Canada, and losses due to the disease can be severe
- first indications of this disease are tiny, water-soaked areas on the stem, leaf or pod either near or in contact with the soil surface
- the growth and spread of infection is very rapid under favorable conditions, and whole plants may be killed in just a few days after symptoms are first observed (plant tissue invaded by the fungus becomes soft and slimy)
- if humidity and temperatures remain high, a cottony white fungus growth soon becomes visible on infected plant parts
- plants with stem infections generally wilt and die, while others with pod or branch lesions may survive – greyish black resting bodies (sclerotia) of varying sizes are formed on the outside or within these dead plant parts
- sclerotia of the fungus are the principal means of carryover of the fungus in the soil – seeds colonized with fungus mycelium may also serve to spread the disease



White mold

- a great number of other broad-leaved crops and weeds serve as natural hosts for sclerotinia
- under favorable conditions during the growing season, sclerotia may germinate to produce mushroom-like structures that, in turn, produce spores – the spores are readily air-borne and may cause direct plant infection (generally, this mode of infection is more common than direct attack from mycelium in the soil)
- sclerotia can persist in the soil for many years, so rotate with cereals and grasses – allow at least four years between susceptible crops such as legumes, canola, mustard and sunflower
- avoid irrigating after the rows close over – wider row spacing and decreased seeding rates may reduce white mold in compact growing varieties, and planting rows in the direction of the prevailing wind enhances air circulation between rows

White mold

- chemical control of the disease is possible if a timely application is made, and complete coverage of plants (with Benlate®, Easout®, Ronilan DF® or Rovral WP®) is essential
- fungicides should cover blossoms because they are easily colonized by the fungus – fungicide applications are most critical when target yields are high, vine growth is heavy and when moist weather occurs during flowering

Gray mold *(Botrytis cinerea)*

Gray mold is a common disease of bean in the Canadian prairies, especially under cool, moist conditions after flowering. It affects all parts of plants, usually starting on senescent organs such as cotyledons and flowers. After infection, the disease spreads rapidly to other tissue by direct contact with diseased tissue. In the field, the disease is most prevalent in crops with a thick, dense canopy. In addition to attacking senescent flowers, the disease is also often initiated through the infection of wounded young bean pods partially buried and bruised by the soil during hilling of bean rows.

Symptoms are usually first seen on senescent cotyledons, flowers and injury caused by hail, sandblasting or machinery damage. Infection first occurs from spores dispersed by wind or rain. The infected sites first develop small water-soaked lesions that expand to form large brown lesions with concentric zones. Under humid conditions, massive grayish brown spores are produced to cover the infected tissues. Sometimes, black sclerotia may be formed on old infected tissues.

Risk of gray mold of bean can be reduced by the use of clean seed, field sanitation and crop rotation. Cereals, forage grasses and corn are rarely affected by gray mold and thus are ideal crops for rotation with bean. Chemical control is rarely considered to be economical. A thin crop canopy may offer some disease control.

Rust *(Uromyces appendiculatus)*

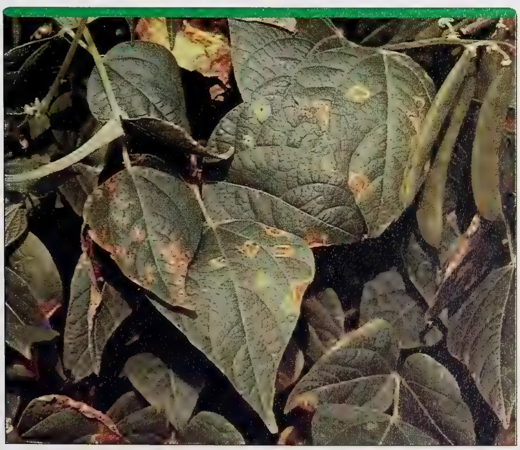
- rust occasionally occurs in Alberta and is found primarily in pinto bean
- it tends to infest late-maturing crops
- rust first appears as small, white spots on the lower surface of the leaves – these spots break open within a few days to expose rust-colored fungus spores on both upper and lower leaf surfaces
- severely infected leaves turn yellow, then brown and soon die (pods and stems may also be attacked)


Rust

- rust fungus can survive on infected bean crop residue and is also spread by wind-borne spores (rust fungus is not transmitted as a seed-borne disease)
- follow a crop rotation that allows a minimum of three years between bean crops
- after harvest, turn under all bean residue as completely as possible

Common Blight *(Xanthomonas phaseoli)* and Halo Blight *(Pseudomonas phaseolicola)*

- blight diseases cause leaf lesions, defoliation, pod lesions and shrunken, discolored seed
- the most prevalent blight is common blight
  - large irregular shaped lesions are surrounded by a distinct yellow zone
  - veins near the lesion are darkened
  - infected pods develop greasy-appearing spots surrounded by a chlorotic halo
  - lesions exude yellow ooze when wet


Common blight

- halo blight is less prevalent, and pinto, great northern and red Mexican varieties have some resistance
  - halo blight first appears as small water-soaked spots
  - these spots soon die, leaving chocolate brown lesions
  - during cool weather, the lesions are surrounded by light green halos up to 1/2 in. (1.3 cm) in diameter
  - the bacteria can cause pod lesions, and these exude a white/cream ooze
- all bacterial diseases are spread by rain splash, and water aids bacteria penetration into leaf pores and wounds
- these pathogens are seed-borne but can survive in non-decomposed bean trash for at least one year
- always plant high quality seed free of bacteria
- bury bean trash and use a three-year (or longer) crop rotation
- avoid cultivation when bean plants are wet

Bean Yellow Mosaic and Bean Common Mosaic Virus

- infected plants are often stunted and spindly, with few pods set and seeds that are off-color and small
- infected leaves have irregular areas of yellowish tissue intermixed with areas of green – leaves may be puckered, twisted and elongated
- plants are seldom killed prematurely and yield loss depends on time of infection
- the disease spreads by plant sap contamination of wounds, insects and infected seed
- many commercially available seed varieties have resistance to virus diseases – plant certified seed and control aphids when they appear in large numbers

Dry Bean Harvesting

Harvest Timing

Bean crops must be cut at the proper stage of maturity. The ideal time to cut bean plants is when 60 to 70 per cent of the pods have turned a buckskin color. Cutting earlier may result in unnecessary shrinkage and wrinkling of the seed coat. Cutting later may result in excessive harvest losses due to pod shelling and the loss of whole pods. Other harvest tips include:

- keep some green vegetation on the plant so that windrows will not be moved by strong winds while the curing process is taking place

Green pod Beginning to turn

- bean crops cut at the proper stage require approximately 7 to 10 days of good drying weather before they are ready for combining
- dry bean will not store in boxes if the moisture content is 18 per cent or higher – the moisture content must be 15 per cent or less if the intended storage is bulk storage
- if bean seed becomes too dry, the percentage of splits and cracks will increase during harvest and post-harvest handling
- the ideal moisture content for combining and storage is between 13 and 15 per cent

Cut dry bean at proper stage

Harvest Systems

System options tend to revolve around two basic concepts: 1) undercut the crop and then use a pick-up header to feed the material into the combine, or 2) straight cut Black and Navy types.

Undercutting

- bean cutters are designed to cut the crop at approximately 3/4 of an inch below the soil surface
- proper completion of the hilling operation during the growing season will definitely make it easier to cut the crop
- the blades on most cutters can be set at two different angles and may be shimmed to alter the angle at which they enter the ground – soil texture, compaction and soil moisture will all be determining factors for the preferred cutter settings

Bean undercutter

- if a proper cutting edge is not maintained, a poor cutting job will cause heavy harvest losses – it's essential to periodically check the performance of the bean cutter in case it requires re-adjustment
- the use of a rod to lift the roots out of the soil after undercutting is a common harvest practice – the rod ensures that no plants are left uncut or are held tightly by the soil
- a rod may be used either at the same time as cutting or immediately before combining, but a rod application should not be used at the same time as undercutting if the crop is overripe, as the crop will be at high risk of blowing – under these conditions, the rod should be used just ahead of the combine
- although windrowing is not a preferred operation in harvesting a bean crop, windrowing may be necessary depending on the type of harvest equipment used:
  - windrowing may be done by using a conventional windrower or a side delivery rake
  - some growers windrow at the same time as undercutting, and others just prior to combining
  - if the crop is to be windrowed just prior to combining, it should be done when the crop is tough to reduce shattering
  - do not windrow any more than can be combined in one day because wind will move the bean swath
- two popular types of combine pick-ups are "Sund" and "Rake-Up"
- pick-up speed should not exceed the ground speed of the combine, to reduce shelling and pod loss

- a number of harvest equipment combinations are:
  1) cut and rod in the same operation at 70 per cent buckskin pod color. Pick-up and combine.
  2) cut the crop at 70 per cent buckskin pod color. Rod just prior to combining. Pick-up and combine.
  3) cut at 70 per cent buckskin pod color. Rod just prior to windrowing. Windrow just prior to combing. Pick-up and combine.
  4) desiccate solid seeded upright/bush bean at 85 to 95 per cent buckskin pod color. Straight combine.
- for normal row crop production of dry bean, option 1 results in the lowest harvest cost per acre while doing a good job of minimizing harvest losses
- option 4 is only viable for upright or bush types grown in a solid seeded field – a flexible header on the combine is necessary for this method of harvest, and lifter guards are also recommended for straight cut operations
- solid seeded bean crops require smooth, level fields, and fields should be rolled shortly after seeding (use empty rollers only)
- vine type varieties (most often grown in southern Alberta) do not straight cut well, as pods often touch the ground, resulting in excessively high harvest losses

Overripe

Harvest undercut

Undercut versus not cut

Combine Settings and Operation

- combines may either be specialized units designed specifically for harvesting dry bean or conventional units with either a cylinder or rotor threshing system
- dry bean is very susceptible to splitting and cracking, so the rpm of the cylinder and the clean grain elevators should be reduced as much as possible – cylinder speeds between 170 and 350 rpm are satisfactory for most threshing conditions
- clearances between the cylinder and concave, and between the wires in the concave, must allow the seed to pass through freely
- the use of perforated sheet metal (3/16 round) and slotted screens in the feeder housing or screening on the combine table will help eliminate dirt from the grain – and save wear and tear on the equipment
- the unloading auger should run at an idle speed to prevent damage to the seed – if you see evidence of seed damage or splitting, make immediate adjustments

Handling and Storage

- box storage can be safely undertaken at 17 per cent seed moisture or less
- if the crop is going into bulk storage, 15 per cent seed moisture or less is required
- handle the crop as gently as possible
- if on-farm storage is used, storing on shop floors, quonsets, etc. and moving with front end loaders is a typical storage and handling method – if dry bean is stored in these types of facilities, ensure floors have

not been stained with oil, grease, diesel fuel, pesticides, etc. as the seed will readily absorb odors from these products and become unsaleable (also make sure the area is free of birds, cats, dogs and mice)

Drying and Conditioning

- dry bean must be conditioned carefully
- bean is considered dry at 17 per cent seed moisture, but safe long-term storage requires moisture contents well below this (see Table 43 for estimates of maximum storage time for various temperatures and moisture contents)
- dry bean must be dried slowly using low temperatures for heated air dryers and optimum relative humidity for natural air drying systems – over-drying increases the chance of splitting, cracking and handling damage, while drying too slowly increases the risk of mold and insect invasion
- bean is graded "Sample" if it contains more than 1 per cent moldy seed, more than 1 per cent heated seed, or if there is an unnatural, objectionable or musty odor

Table 43. Estimated maximum duration of dry bean storage (in weeks)

Storage Temperature	Per Cent Moisture Content							
°C	11%	12%	13%	14%	16%	18%	20.5%	23%
25	31	22	16	11	7	4	2	0.5
20	55	40	28	19	13	7	3.5	1.5
15	100	75	50	30	20	12	6	3
10	200	140	95	60	38	20	11	4.5
5	370	270	170	110	70	39	20	9

Source: APGC Pulse Manual, 1993

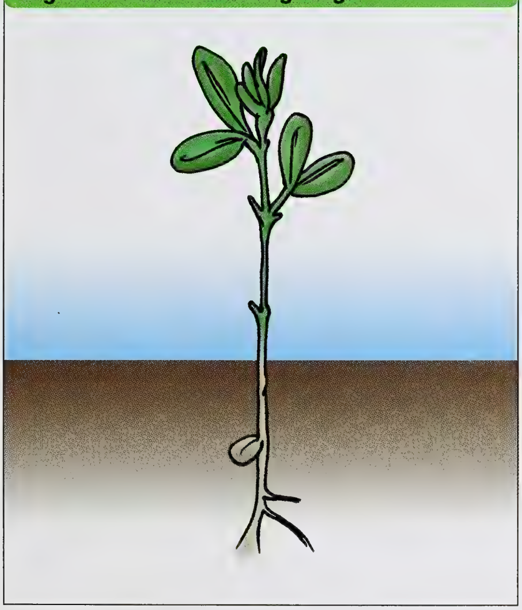
lentil

The Lentil Plant

Description

Lentil is self-pollinating. Early maturing varieties flower at the 11th or 12th node stage and later maturing varieties at the 13th or 14th node stage. Flowers appear in clusters of two or three at the base of the upper leaves, and flowering will be delayed or flowers will abort in high moisture and high fertility conditions.

Figure 24. Lentil seedling stage



Other characteristics include:

- the lentil plant usually has two or more secondary branches rising from the main stem
- the majority of crop yield comes from branches from the uppermost nodes of the main stem, below the first flower node
- seed pods are less than an inch in length and contain one to two seeds
- seeds are lens-shaped with a range of seed coat colors as well as yellow, green or red cotyledons

Adaptation

Lentil is well-adapted as a stubble crop in the Dark Brown soil zone when soil moisture reserves are adequate. The Dark Brown soil zone's growing season is long enough to accommodate more indeterminate lentil

A branching lentil seedling

varieties.

The Thin Black soil zone provides adequate soil moisture reserves for successful lentil production. However, the shorter growing season limits production to determinate varieties (Persian type).

Young lentil seedlings have some tolerance to above-ground damage caused by spring frosts, heat canker. Regrowth can start from buds or nodes that remain underground during early growth stages, although this later development will result in later crop maturity.

The Black and Grey Wooded soil zones receive excess precipitation for top-quality lentil production. Excess soil moisture delays maturity and encourages disease. These soil zones have growing seasons that are not suited for top quality lentil production.

- lentil will not tolerate flooding or salinity
- the plant is moderately drought tolerant, needing 6 to 8 inches of precipitation for optimum yields
- lentil requires a soil pH from 6.0 to 8.0
- high moisture promotes excess vegetative growth, prolongs maturity, reduces seed yield and encourages the development of disease

High moisture damage

Market Types and Uses

Canada is a major exporter of lentil. Most international markets prefer the large Laird, a Chilean type lentil. Eston, a Persian type, makes up about 10 to 15 per cent of Canadian lentil production and fits into markets where a firm cooked seed is important. Alberta produces two major groups of lentil: a Chilean type and a Persian type.

Other niche markets include red-split lentil, zero-tannin lentil and small black (Indian Head) lentil used primarily for green manure plow-down. Lentil can also be used as livestock feed when the product grades lower than Canada No. 3.

- seed size determines lentil type:
  - Chilean type is larger than the Persian type, with seed size averaging 60-70 grams or higher per 1000 seeds
  - Persian type is small seeded, with seed size averaging 30-40 grams or lower per 1000 seeds
- seed coat colors range from clear to green, brown, grey, blotched purple or black
- cotyledon color varies – yellow, red or green

Production Economics and Marketing

Introduction

The keys to obtaining the right price for lentil:

- know your production costs
- know the markets you are targeting
- know the quality of lentil you have grown
- understand different types of contracts
- study and use market information sources

Costs of Production

Table 44 shows production and break-even techniques that may help producers plan a marketing strategy. Start by calculating a break-even price using average yields and a realistic estimate of production costs. Knowing the break-even price is critical to knowing when to sell and at what price. (Costs can vary from farm to farm, so use figures from your own farm.)

In this example, production costs are for Eston lentil. If lentil yields 1100 pounds/acre, the price required to cover all the costs would be **$187.00 divided by 1100 lbs./acre = $.17/lb. or, $187.00 divided by 1500 lbs./acre = $.125/lb**. In other words, the break-even price is 12.5 to 17 cents per pound.

Table 44. Costs of production for Eston lentil

Input		$/acre
Seed*	45 lbs./acre @.16/lb.	$ 7.20
Inoculant	dry peat with sticker @ $1/bu.	.80
Fungicide	Crown seed treatment	5.40
	**Bravo 500 - 2 applications@.8 L/acre	26.60
Fertilizer	Nitrogen - 8 lbs. @.25/lb.	2.00
	Phosphorous - 30 lbs. @ $.30/lb.	9.00
	Potassium - 15 lbs. @ $.20/lb.	3.00
Herbicides	Broadleaf and grassy weed control	26.00
Crop insurance		7.00
Fuel, oil and lube		9.00
Machinery repairs		9.00
Building repairs		1.00
Hired labor		3.00
Custom and machine rental		2.00
Operating loan interest		3.00
Direct Cash Costs		**$ 114.00**
Property taxes		4.00
Farm insurance		2.00
Utilities (farm share)		2.00
Depreciation		15.00
Operator labor		15.00
Land rent or ownership cost		35.00
Total Indirect Cash Costs		**$ 73.00**
Total Costs		**$ 187.00**

* seed input costs can vary depending on seed size.
** The Bravo 500® treatment can be eliminated if a variety with ascochyta resistance is seeded.

Rotational Benefits

Economic benefits are only part of the reason for growing lentil. Lentil offers rotational benefits as well:

- decreased need for nitrogen inputs to the following crop
- decreased costs for herbicides and fungicides in a following crop
- increased yields of the following crop

- increased quality of the crop grown the year after lentil (for example, protein premium on wheat)

Market Choices

- lentil should be grown for a specific market, which should be identified before you buy seed
- Chilean type lentil, such as Laird, is preferred by international markets
- Persian type lentil, such as Eston, fits into markets where a firm cooked seed is important
  Niche markets include:
  - red-split lentil
  - zero-tannin lentil
  - small black (Indian Head) lentil used primarily for plow down
  - Spanish brown
  - French green
  - seed production
- **Check all available market information sources and market outlooks for lentil**: there are numerous weekly market information newsletters, satellite information sources (DTN, Global Link), Internet web sites (STAT Publishing) and radio commentaries
- a list of lentil buyers can be found at www.agric.gov.ab.ca/crops/special/directory/index.html

Global Production and Market Outlook

The world produces 2.5 million metric tonnes of lentil per year. India, Turkey and Canada are the world's largest producers, but Canada is the largest exporter. Turkey, the U.S. and China are Canada's biggest competitors in the export market.

Canada

Canada's average lentil production from 1994 to 1998 was 420,000 tonnes per year. About 22 per cent of this production is used domestically for seed, feed and human consumption. Canadian lentil exports averaged 280,000 tonnes per year from 1994 to 1998, with exports widely distributed among 75 countries.

Canadian Exports

- exports to Europe averaged 60,000 tonnes per year, mostly to Belgium, France, Germany and the Netherlands
- exports to Mediterranean countries averaged 63,000 tonnes per year, with Spain, Italy and Greece as the major buyers
- about 92,000 tonnes per year are shipped to South America, with most countries being buyers
- Mexico, Panama and the U.S. are the major Central and North American importers of Canadian lentils
- Arab and African countries import 42,000 tonnes per year on average, with the highest volume customers being Algeria, Egypt, Israel and Morocco
- the Pacific Rim market has averaged 2,600 tonnes per year and is growing

Overall, the global market for Canadian lentil is stable and increasing slowly. World supply is the greatest factor affecting farm lentil price changes from year to year.

Sampling

- know the quality of the lentil you've produced – harvest-time is best for taking samples:
  - take the same number of cross-section samples of the grain as each load is unloaded, to provide a representative sample for each bin
  - store the composite sample for each bin in a clearly marked container
  - submit representative sub-samples to determine grade and to potential buyers
- grading services are available from grain buying companies or by sending a sample to the Canadian Grain Commission (Tables 45 and 46)

Grading Lentil

Lentil samples are considered commercially clean when they have dockage material of up to 0.2 per cent by weight. Samples with dockage material of more than 0.2 per cent by weight are considered not commercially clean and may not be shipped except with the Canadian Grain Commission's permission.

Damage

- **Frost damage**: normally indicated by a combination of wrinkling and close adherence of the hull to the endosperm, which is somewhat translucent in appearance
- **Heat damage**: limits of heat damaged seeds specified in grade definitions apply to distinctly heated lentil; in samples containing lightly damaged seeds (with tan-colored meats), if a distinct odor is detected, the seeds are classed as heated; otherwise, they are classed as damaged – samples containing over 1.0 per cent by weight of heated lentil or lentil with a heated or distinct musty odor are graded **Lentil, Canada, Account Heated**

Table 45. Grades of red lentil (Canada)*

Grade Name	Standard of Quality / Degree of Soundness	Maximum Limits of – Damage: Heated	Damage: Peeled, Split and Broken	Damage: Other Damage	Damage: Total	Foreign Material: Stones	Foreign Material: Total
No. 1 Canada Red	Uniform in size, of good natural color	About 0.2%	2.0%	1.0%	2.0%	About 0.1%	About 0.2%
No. 2 Canada Red	Uniform in size, of reasonably good natural color	About 0.5%	3.5%	2.0%	3.5%	About 0.2%	About 0.5%
Extra No. 3 Canada Red	Uniform in size, of fair color	About 0.5%	5.0%	5.0%	5.0%	About 0.2%	About 0.5%
No. 3 Canada Red	Poor color	1.0%	10.0%	10.0%	10.0%	About 0.2%	1.0%

*Canadian Grain Commission – Grades of Grain – August 1, 1998

Table 46. Grades of lentil other than red (Canada)*

Grade Name	Standard of Quality / Degree of Soundness	Maximum Limits of – Stained	Damage: Heated	Damage: Peeled, Split and Broken	Damage: Other Damage	Damage: Total	Foreign Material: Stones	Foreign Material: Total
No. 1 Canada	Uniform in size, of good natural color	1.0%	About 0.2%	2.0%	1.0%	2.0%	About 0.1%	About 0.2%
No. 2 Canada	Uniform in size, of reasonably good natural color	4.0%	About 0.5%	3.5%	2.0%	3.5%	About 0.2%	About 0.5%
Extra No. 3 Canada	Uniform in size, of fair color	7.0%	About 0.5%	5.0%	5.0%	5.0%	About 0.2%	About 0.5%
No. 3 Canada	Poor color	-	1.0%	10.0%	10.0%	10.0%	About 0.2%	1.0%

*Canadian Grain Commission – Grades of Grain – August 1, 1998

- **Peeled, split and broken**: includes lentil otherwise sound but which is less than three-quarters of whole kernels or has less than one-half of the seed coat intact – lentil with cracked or chipped seed coats is considered sound when the halves are firmly held together and will not form part of the percentage by weight of peeled, split and broken lentil
- **Rime**: lentil completely and densely covered with white rime (the adhered lining of the seed pod) is considered damaged in any grade – when rime is sparse enough to expose the soundness of the grain, the sample is classed as sound, and the rime is considered in the general appearance of the sample
- **Sprouted lentil**: lentil is considered sprouted when the hull has parted over the area of the germ and sprouting is evident

Foreign material

- **Stones**: hard shale, hard fertilizer pellets, earth pellets that do not crumble under light pressure and other

non-toxic materials of similar consistency are considered stones – samples of western lentil containing over-grade tolerance up to and including 2.5 per cent stones by weight are graded **Lentil, Rejected (grade), Account Stones**; samples containing over 2.5 per cent stones by weight are graded **Lentil, Sample Salvage**

- **Ergot**: this disease results in a fungus growth in place of the kernel – samples containing over 0.05 per cent ergot by weight are graded **Lentil, Sample Canada, Account Ergot**
- **Sclerotia**: are the masses of fungal tissue produced by the soil-borne fungus *Sclerotinia sclerotiorum* – samples containing over 0.1 per cent sclerotia by weight are graded **Lentil, Sample Canada, Account Admixture**
- **Other foreign material**: includes other domestic grains, weed seeds, earth pellets and material such as pod and stems – samples containing over 1.0 per cent by weight of other foreign material are graded **Lentil, Sample Canada, Account Admixture**

Odor

Samples with any type of unnatural or objectionable odor (other than that of heated or fire burnt kernels) are graded according to the basic quality of the sample, the type and degree of odor and the presence of visible residue causing the odor.

Samples with a distinct odor not associated with the grain quality are graded **Lentil, Sample Canada, Account Odor**. Samples having a heated odor are graded **Lentil, Sample Canada, Account Heated**. Samples with a fire burnt odor are graded **Lentil, Sample Canada, Account Fire Burnt**.

Stained

Numerical tolerances for "stained" include all distinctly discolored or mottled lentil. This category includes damaged seeds that are also stained. Lentil with a variable degree of brown discoloration (water spot) that is significant and distinctly identifiable on the seed coat are considered stained.

Color

Color is determined on the basis of the cleaned sample after the removal of stained and damaged lentil:

- **good natural color**: sound and well matured with a good natural color
- **reasonably good natural color**: moderately immature, lightly earth-tagged or lightly discolored from storage or other natural causes
- **fair color**: immature but not green, moderately earth-tagged or otherwise moderately discolored from natural causes
- **poor color**: cannot be considered of fairly good color but is not severely earth-tagged, immature or severely stained
- **sunburned**: the normal discoloration of lentil that occurs during storage – the color may vary from light tan to brown or very dark brown, depending on the duration and conditions of storage
- **blue-black**: the dark blue hull discoloration that is natural on some lentil

Contracts

One method of selling lentil is through contracting. Contracting a portion of the crop can reduce market risk. There are several types of contracts, each with advantages and disadvantages:

Production Contract

- guarantees the delivery of some or all production to a buyer
- may or may not specify the price or total volume accepted
- some production contracts specify price for a certain volume, with over-deliveries accepted only by mutual agreement between buyer and seller and priced at the market on delivery
- a date of acceptance for delivery may be specified, and some contracts will implement a storage fee to be paid to the producer after a certain date
- some seed growers or seed dealers will contract lentil production for seed purposes – while these contracts can be profitable to the grower, consider the extra management required to produce high-quality seed

Deferred Delivery Contract

- also referred to as a DDC, this contract is an agreement to deliver a specified tonnage of a certain grade of product to the buyer by a certain date in return for a guaranteed price
- advantages to the producer of a fixed price and delivery opportunity can be considered a disadvantage later on if higher prices are offered by other buyers
- most deferred delivery contracts include escape clauses to cover production failure due to adverse weather

- any contract that specifies a grade should also state how grades different from the one specified are handled – if other grades are accepted, the price and terms should be stated in the contract
- the contract should specify storage charges to be paid by the buyer to the seller, should the buyer delay delivery beyond that stated in the contract

Dealer or Producer Car Contract

- similar to other deferred delivery contracts except shipping is by producer-loaded railcar
- the difference between a dealer car and producer car is that the dealer car is allocated to a grain dealer, who in turn offers the railcar to a producer for loading, while the producer car is allocated directly to a producer for loading
- dealer car loaded product may have a lower price than a producer car since the profit for the dealer is part of the price – however, a dealer car often has a better price than sale of the same product through the elevator system
- some trade-offs exist between dealer/producers cars and elevator delivery:
  - delivery to the elevator is usually more convenient, involves less administration and can often provide mixing/blending benefits to improve grade
  - deliveries to an elevator can also result in immediate payment, while payment for railcar delivery is made after unload, which can be three or more weeks after the car is loaded

Contract Tips

Read the contract before signing it. This may mean getting an unsigned copy from the buyer, taking it home and taking the time to study it. Remember, contract contents can be amended by mutual agreement, and a section in disagreement can be omitted or amended to suit both parties. Answering the following can help you get the best contract arrangement:

- Are all charges accounted for?
- Is the quoted price a net price at the delivery point, or will there be additional freight charges?
- Is a grade or specification stated? Are other grades deliverable and, if so, at what premium or discount?
- How is dockage assessed? Is freight to be paid on dockage? Will dockage be paid for and at what price? How are grade and dockage disputes settled?
- Is a delivery date specified? What happens when one party defaults on delivery date? Will the buyer pay storage charges after a certain date? Will the buyer pay post-delivery interest charges after a certain date?
- What protection does the seller have in case of payment default by the buyer?

Electronic Marketing

Two electronic markets are available in Alberta, and both are available through the Internet:

A.J. Bat (http://www.canadagrain.com)

- **A.J. Bat (Allan Johnston Bid-Ask-Trade)** is a site where buyers and sellers can list what they want to buy and sell
  - lot size, terms of sale and price are listed
  - there is no charge for buyers or sellers to post a bid or ask – it is between buyer and seller to work out the trucking and payment directly
  - if there is a grading problem, then the Canadian Grain Commission is consulted
  - a yearly subscription gives access to reports and listings
- **A.J.BATexport Trading Page** is where producers, processors and buyers (both locally and internationally) post product for sale or product wanted
  - all prices are converted to a common point of export, depending on the crop
  - individual companies and processors then work back the price to their point of origin

Ag-Direct.Com (http://www.ag-direct.com)

- **Ag-Diret.Com** is an electronic marketplace for feed grains where customers can trade in specific regions across Western Canada
  - has approval of the Alberta, Saskatchewan and Manitoba Securities Commissions to operate as an Exchange
  - allows trading in the spot, forward and basis markets
  - the system was designed by grain traders for grain traders
  - all potential users are closely screened
  - AgraLink handles all payments and has an optional freight exchange service for trucking
  - since there is a higher level of security and services, the fee is higher than with A.J. Bat

Lentil Varities

Table 47 lists varieties being tested in the Alberta Regional Variety Test Program for Lentil. Data presented are from 1994-98. Data are updated annually and published as **Alberta Agriculture Agdex 140/32-1**, ***Varieties of Special Crops for Alberta***.

Table 47. Lentil varieties for Alberta

Alberta Lentil Regional Test Data - 1994 to 1998								
Variety	**Station years**	**Yield as % of Laird**	**Days to bloom**	**Days to maturity (+/-)**	**Stand 1=E, 9=F**	**Seed weight (g/1000)**	**Plant height (cm)**	**% Seed moisture at harvest**
CDC Glamis(a)	5	115	56	-0.5	6.5	61	44	5.5
CDC Gold	20	132	56	-2.4	5.2	44	36	10.0
CDC Matador	21	134	56	-4.6	5.2	31	36	8.8
CDC Milestone	10	151	52	-4.7	6.2	38	33	7.0
CDC Redwing	20	126	56	-3.6	4.5	37	34	9.8
CDC Richlea	30	144	55	-3.3	6.0	53	35	9.7
CDC Royale	20	112	56	-3.6	5.8	40	34	8.9
CDC Vantage (a)	5	149	52	-2.5	7.0	48	40	5.8
Eston	30	137	53	-6.0	6.0	35	32	9.0
Indian Head	30	135	62	-3.2	3.5	24	37	8.8
Laird	30	100	59	0.0	5.2	71	40	11.1
Red Chief	20	97	53	-2.8	5.5	56	36	10.5
Rose	30	119	52	-4.3	6.2	45	34	9.9
ZT 4	20	89	57	0.4	4.0	45	36	10.9

Yield (kg/ha) of Laird = 1618, Days to maturity 111: (a) first-year entries in the Regional Tests
New varieties-CDC MATADOR (Spanish brown type), CDC REDWING (small red type) and CDC MILESTONE (Eston Type) are ascochyta resistant; CDC ROYALE (French green type); CDC VANTAGE (replacement for CDC RICHLEA); CDC Glamis (replacement for LAIRD); CDC GOLD (a zero-tannin variety).

Pre-Seeding Considerations

Lentil is a management-intensive crop. Before planting lentil, many issues need to be considered, which will often affect the crop you grow before lentil. These issues could also determine whether lentil is desirable in your rotation at all.

- lentil cannot tolerate residues from the following herbicides: Accord®, Ally®, Assert®, Banvel®, Curtail M®, 2,4-D, Lontrel®, MCPA, Muster®, Prevail®, Rustler®, Unity® or Prestige®. If a residual herbicide problem is suspected, check the manufacturer's label (if the label does not clearly state whether lentil can be grown in the given situation, contact the manufacturer directly)
- lentil has a greater risk of developing sclerotinia stem rot if it follows canola, mustard, sunflower, field pea or fababean in your rotation, so lentil should follow cereal crops
- volunteers from previous crops can reduce lentil's yield and quality:
  - volunteer canola and tame mustard can be difficult to control with herbicides
  - volunteer barley and durum wheat are difficult to separate from large-seeded lentil
  - volunteer hard red spring wheat is difficult to separate from small-seeded lentil
  - failure to control volunteer cereals can result in reduced lentil grade
- lentil lacks the number of effective herbicide options that some other crops have (for example, no herbicides offer in-crop control of Canada thistle or perennial sow-thistle in lentil) – only fields free from these weeds or fields with sufficient control measures

(pre-harvest glyphosate) the previous cropping season are suitable for lentil production

- lentil should not be grown on the same field in consecutive years because of the risk of severe ascochyta blight infection:
  - ascochyta can spread from lentil stubble from last year's crop to adjacent fields containing the current year's crop
  - ascochyta blight can also be spread by infected seed
  - anthracnose can be transferred by wind-blown dust between adjacent lentil plantings or lentil plantings and adjacent lentil stubble
- lentil seed is very susceptible to mechanical damage during seeding, harvesting, cleaning and storage operations (especially with dry lentil seed at 14 per cent or less moisture) – although damage is often not visually apparent
- reduced germination and vigor can also result from herbicide residues
- to avoid germination and vigor problems, all samples should be tested for germination, seed vigor and seed-borne ascochyta blight, and use certified seed
- Crown® (carbathiin and thiabendazole) is registered as a seed-applied or drill box seed treatment for control of ascochyta seedling blight and seed rot (highly recommended for zero-tannin lentil varieties) – the product is compatible with nitrogen-fixing bacteria found in lentil inoculant
- Vitaflo 280 (carbathiin and thiram) is a newly registered fungicide for control of seed decay and damping off. This product should not be directly mixed with lentil *rhizobium* (apply in sequence)
- lentil can satisfy up to 75 per cent of its own N demand if properly inoculated – use single strain inoculant products containing *rhizobium* bacteria specifically for lentil
- inoculant comes in three forms:
  1) liquid,
  2) peat-based (some are self-stick products requiring no commercial sticker)
  3) granular
- *rhizobium* are living organisms and must be handled carefully to ensure viability – always consult product labels for handling instructions and application rates (see Inoculation of Pulse Crops in this publication for more details)

Fertility Requirements

Soil testing is the best way to determine lentil's fertility requirements and is recommended before every lentil crop.

Nitrogen

As well as determining the amounts of nutrients required, soil testing allows producers to screen fields for excessive nitrogen (N) content. Too much soil N reduces yield by encouraging rank plant growth and delaying maturity.

Because lentil can fix up to 75 per cent of its own needed N, fertilizer N is rarely required. If called for, N should never be seed-placed. Instead, applications before seeding (or side-banding where there is separation of the seed and N band) are recommended.

Phosphorous

Lentil is moderately tolerant to seed-placed phosphate. Up to 15 lb. of P_2O_5 per acre may be safely applied with the seed. If greater amounts of phosphorus are needed, side-banding during seeding is the best way. The closer phosphorus can be placed to the seed without damaging it, the greater the pop-up effect (quicker seedling emergence) and the greater the seedling vigor. Banding of phosphorus prior to seeding can be done, but is less efficient in supplying needed phosphorus to the lentil crop.

Use Table 48 as a guide in interpreting your soil test and deciding how much phosphate fertilizer is required.

Table 48. Phosphorus fertilizer recommendations for the different soil test areas used by the Alberta Agriculture Soil and Animal Nutrition Lab using the Miller-Axley method

Soil Test Level P (lb./ac.) (0-6 inch depth)	P_2O_5 Recommendation (lb./ac.)					
	Brown	Dark Brown	Thin Black	Black	Grey Wooded	Irrigated
>80	0	0	0	0	0	0
60-80	20	20	20	20	20	20
50-60	20	20	25	25	25	30
40-50	20	25	30	30	30	40
30-40	25	30	35	35	35	45
20-30	30	35	40	40	40	50
10-20	35	40	45	45	45	55
0	40	45	50	50	50	60

Potassium and Sulphur

Potassium (K) and sulphur (S) are usually adequately supplied by most soil types. The same holds true for micro-nutrients: namely boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn). If deficiencies are a concern, soil testing is especially recommended. Test soil to a depth of 24 inches to determine if sulphur fertilizer is required.

Use Table 49 as a guide in interpreting your soil test and deciding how much sulphur fertilizer should be applied.

Table 49. Sulphur fertilizer recommendations for lentil used by the Alberta Agriculture Soil and Animal Nutrition Laboratory using the CaCl method

Soil Test Level SO_4S (lb./ac.) (0-24 inch depth)	Sulphur Recommendation (lb./ac.)					
	Brown	Dark Brown	Thin Black	Black	Grey Wooded	Irrigated
>20	0	0	0	0	0	0
20	5	5	5	10	10	10
15	10	10	10	15	15	15
10	15	15	15	20	20	20
5	20	20	20	25	25	25
0	20	20	25	25	25	30

Seeding Management

Field Selection

To make lentil harvesting easier, choose fields that are level and free of stones or dirt clumps. This choice is important since the final crop canopy is not very tall.

Timing of Seeding

- early seeding (mid-April in southern Alberta, late-April in south-central Alberta and early-May for central and northern Alberta) usually results in the highest yields and quality
- early seeding results in taller plants that hold their bottom pods higher off the ground, which facilitates easier harvesting

Lentil seedlings

- seeding can begin when soil temperature is 4-5° C or warmer at depth of seeding
- lentil seedlings can tolerate light frosts and will regrow (with a resulting delay in maturity) if damaged by heavy frosts
- avoid excessive soil moisture at seeding because these conditions will increase stand loss due to seed or seedling rots
- later seeded crops (mid- to late-May) of short-seasoned varieties will develop quickly in warm, moist weather and can sometimes catch up to an earlier seeded crop – the trade-off is that while crop development speeds up at higher temperatures, lentil can experience heat stress and slower crop development
- temperatures exceeding 27° C will often reduce the seed set of later seeded crops
- final allowable seeding date for lentil insured by Agriculture Financial Services Corporation (AFSC) is May 15

Seeding Rates

- recommended seeding rates for lentil are 40 lb./ac. for small-seeded types and 80 lb./ac. for large-seeded types – rate is based on desired plant stand density of 10 plants per ft^2 or 108 plants per m^2
- actual seeding rate should be calculated based on seed germination and vigor tests – it will be necessary to increase seeding rate to compensate for poor quality seed

Good plant population, competitive crop

- like other crops, low seeding rates of lentil will result in poor crop competition with weeds, reducing yields
- do not seed more heavily than the recommended rate, because densely populated stands encourage disease development
- if seed is to be treated with fungicide and/or inoculated with seed-applied inoculant, calibrate seeding equipment with treated seed, since seed coatings will affect the metering and flow of seed through equipment

Green lentil

Red lentil

Indian Head lentil

For information on seeding by plant population, see Using 1,000 Kernel Weight for Calculating Seeding Rates and Harvest Losses, Agdex 100/22-1.

Seeding Depth

Always seed lentil into moisture because of its relatively large seed size. Avoid excessive spring tillage. Lentil can emerge from relatively deep seeding, although lower plant vigor, greater incidence of disease and lower yields may result. Optimum seeding depth under normal moisture conditions is 1 to 2 in. (2.5 to 5 cm) with seeding depths of 2 inches or more if you plan to use the herbicide Sencor®.

Seeding Equipment

Lentil can be seeded with all types of conventional seeding equipment, keeping in mind the following points:

- take care when using air-seeders, since excessive air velocity can damage dry seed (less than 14 per cent seed moisture) – air velocity should be just high enough to prevent line plugging
- large-seeded lentil is more prone to damage than small-seeded types – use belt conveyors to move seed; if using conventional augers, run them as slowly and as full as possible
- mechanical damage to dry lentil seed (less than 14 per cent seed moisture) can be reduced by seed moisturizing
- if seeding equipment has on-row packing, no further packing is usually required
- seeding with discers or air-seeder units without packing wheels should be followed with harrow packing
- to prevent crusting, avoid packing operations on wet soils – seed needs oxygen for germination
- any harrow packing operation should be done immediately after seeding because lentil emerges quickly
- lentil is well-suited to direct seeding practices

Post-Seeding Considerations

Crop Rolling

Since lentil is harvested close to the ground, smooth soil surfaces and stone-free conditions are desirable. A land roller can be used between seeding and the fifth node stage (no later) to level fields and push down stones. Be mindful of crop staging; rolling after the fifth node stage can damage stems and branches and can seriously reduce yields. Water ballast is not needed, since packing is not the goal of this operation.

- Do not roll
  - before emergence if soil is excessively wet and/or prone to crusting.
  - after emergence if a frost has just occurred, which may cause crop damage and yield loss due to increased crop stress
  - when plants are damp from rain or dew – in these conditions, plant leaves adhere to the roller and tear, spreading diseases like ascochyta

To avoid possible yield reductions and crop damage due to stress, leave at least a two-day break between rolling and herbicide applications. Herbicide application is the recommended first operation if a choice has to be made between the two. The damage to yield by weed competition will be more severe than losses associated with a crop that has not been rolled.

"N starvation"

N starvation may occur during and immediately following emergence. Lentil plants begin root nodule formation

about two weeks after plant emergence. During this period, plants may turn pale green, called the "period of N starvation," and it is normal. With proper inoculation, nodules will soon start to function and eliminate this problem.

- check the nodulation process by digging individual plants approximately four weeks after emergence – root surfaces and especially areas of the crown should display small swellings, which are the nodules
- if no nodules are visible at four weeks after emergence, plants should be re-sampled in another week or two. If nodulation failure is occurring, a nitrogen application may be advisable to preserve yield potential
- yellowing of a lentil crop may also be due to flooding, which deprives roots of needed oxygen (these conditions, if they persist, will also cause inoculant failure). Yellowing may also be a condition of seedling root rot
- **soils with high N content prior to planting will inhibit nodule formation and are unsuitable for lentil production**
- sample plant root systems at early flowering (nodule presence and color are the important factors):
  - at flowering, each lentil plant should have several elliptical shaped nodules on its root system
  - these nodules will appear in clusters and should be pink – the pink color indicates that the nodules are active
  - the proper number of nodules may be difficult to determine because nodules adjust their size and activity level in relation to their number

Lentil Irrigation and Water Use

Eston, a determinate type, is better suited for production under irrigation. This type does not display the delayed maturity, increased disease and lower yields normally associated with high moisture. Even with Eston, however, excess water can cause problems.

Irrigated lentil production requires careful management because lentil dies quickly when flooded.

Irrigation research in Alberta has shown that Eston yields are highest when plants use 8 to 14 in. (20 to 36 cm) of water. Although lentil uses water efficiently, it is a shallow-rooted plant and therefore needs significant soil moisture to produce optimum yields.

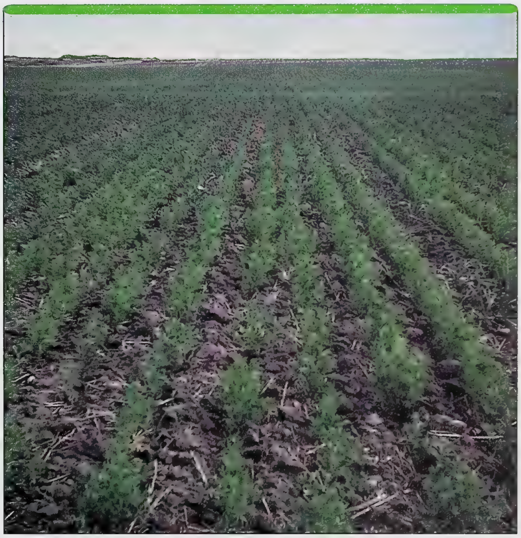
- when irrigating, don't let water accumulate on the soil surface, especially at seeding time
- apply 0.8 to 1.2 in. (2 to 3 cm) of water in early June to prevent plant stunting and yield reduction, especially if plants are starting to display drought symptoms
- if metribuzen (Sencor® or Lexone®) is applied to the crop, delay irrigation for at least two weeks after spraying – this will prevent leaching of the herbicide into the lentil rooting zone, which could result in crop damage
- irrigation is usually discontinued when flowering begins – moisture stress at this time is desirable and will promote flowering
- approximately 4 in. (10 cm) of water is recommended after the stress period – this will encourage pod formation and filling.
- after this time, irrigation should be discontinued – moisture stress on the crop will be needed to enhance crop maturity

Weed Control in Lentil

Since lentil is a short crop with a thin crop canopy, weed competition can greatly reduce yields. Weed control is the critical step in preserving yield potential.

Weeds such as wild tomato or round-leaf mallow, which rarely reduce yield in competitive cereal stands, can be problem weeds in thin lentil crops. Apart from reducing yields, these low-lying weeds will interfere with harvest.

No post-emergent chemical products are available for many weeds, including wild tomato and round-leaf mallow.



Good weed control

Importance of good weed control (sprayed on the right)

The Year Before Lentil

A lentil weed control program starts the year before planting, with proper field selection and management.

- fields should receive either pre- or post-harvest glyphosate treatments
- avoid late-fall application of 2,4-D, MCPA, Banvel® or Rustler® (which contains dicamba) for the control of winter annuals, or early spring application of these herbicides for pre-seeding weed control (these applications can cause crop injury, especially under dry, cool conditions)
- only fall application of trifluralin products such as Advance®, Rival®, Bonanza 10G® or Treflan® is recommended (Sencor® can be used in a fall-applied tank mix with liquid Treflan®)
- spring application of these products can result in crop injury, reduced seedling vigor and uneven plant stands due to a dried-out seed bed
- even with fall herbicide applications, it's important that the crop emerge quickly to avoid injury – deep seeding and cold or dry soil conditions can aggravate crop injury problems associated with trifluralin products

The Year of Lentil Production

In the year of production, weed control starts early with a pre-seeding application of glyphosate, provided weeds are actively growing. Effective use of glyphosate can compensate for the limited number of post-emergent herbicides. Pre-seeding tillage can also be used, but this operation can reduce seedbed moisture.

Lentil crops have few post-emergent herbicide options. Most grassy herbicides cause little or no crop damage although Hoe-Grass® (diclofop methyl) will cause leaf cupping and leaf burn if applied during hot, humid weather.

Broadleaf herbicides generally cause more damage

- Sencor® (metribuzen) should not be applied to lentil seeded less than 2 in. (5 cm) deep or on soil with less than 4 per cent organic matter content
- full rates of Sencor® applied during hot weather will result in leaf burn
- to avoid crop injury, Sencor® should only be applied to lentil in the second to fifth node growth stage – late applications (after the fifth node) will severely damage the crop and are not recommended
- the safest and most effective strategy is often a split application: half of the full Sencor® rate at the second node stage followed by another half rate 10 to 14 days later

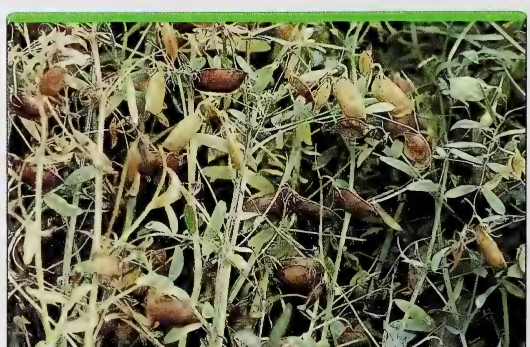
For detailed information on applying herbicides to lentil, as well as information of the weeds controlled, consult Agdex 606-1, Crop Protection.

Diseases of Lentil

This section outlines the key diseases in lentil, along with information on how they can be recognized and controlled.

Ascochyta Blight

- caused by *Ascochyta fabae* f. sp. *lentis*
- can spread rapidly on stubble or seed in a field with cool, wet conditions
- spores are spread through rain splash – they can survive up to five years on the soil surface and up to 30 years in the seed



Ascochyta blight

Symptoms

Ascochyta Blight

- symptoms appear on leaflets, pods and stems as tan spots surrounded by a dark margin
- tiny black specks known as pycnidia occur in the center of the spot
- branch tips wilt, turn brown and often die – premature drop occurs from infected leaflets
- can also cause flower and pod abortions – infected seeds turn purplish-brown and are often shriveled and smaller in size (severely infected seed can also have whitish patches of mycelia, strands of threadlike material, with tiny black pycnidia on the surface)

Ascochyta Blight

Prevention and Control

- allow at least 4 to 5 years between lentil crops
- use disease-free seed
- seed can be treated with Crown® (carbathiin and thiabendazole) fungicide
- Bravo 500® (chlorothalonil), a post-emergent fungicide, can be applied at early flowering and can be repeated up to three times if conditions favor disease development

Anthracnose

- caused by *Colletotrichum truncatum*
- can be borne by seed or stubble
- since spores are spread by splashing rain, anthracnose thrives under warm, moist weather, frequent showers and dense canopies
- spores can survive on stubble for up to two years

Symptoms

- appears as grey to cream-colored spots on leaves and tan to brown lesions on stems
- the entire lower stem may become covered in lesions, giving it a brown, rough appearance
- this stage is generally followed by die back of leaves and extensive loss of leaves – entire plants may die back and stems take on a blackish color
- brownish seed discoloration can also occur

Prevention and Control

- allow 4 to 5 years between lentil and other susceptible crops such as pea and fababean
- use disease-free seed
- apply the fungicide Bravo 500® at early flowering, and repeat if conditions for disease development are favorable
- Crown® can also be used as a seed treatment for seed-borne pathogens of this disease

Anthracnose first stages

Anthracnose final stages

Botrytis stem and pod rot

Botrytis Stem and Pod Rot

- caused by *Botrytis cinerea* Pers. ex Fr.
- botrytis stem and pod rot is also known as grey mold
- can be seed or soil-borne and favors cool, moist conditions and a thick plant canopy, such as found under irrigation
- more common on early-seeded crops
- infected seed produces infected seedlings, which die soon after emergence

Symptoms

- botrytis stem and pod rot first appears on lentil flowers as a dirty, white moldy growth
- watch for wilting, premature ripening, failure of pods to fill and dead infected crop areas
- a greyish, moldy growth occurs on the surface of the pods and stems

Prevention and Control

- since no fungicides are registered for control at this time, the only practical prevention measure is to avoid growing lentil under irrigation

Sclerotinia Stem and Pod Rot

- caused by *Sclerotinia sclerotiorum* (Lib.) de Bary
- sclerotinia stem and pod rot flourishes under dense canopies and high humidity

Symptoms

- the first sign of sclerotinia infection will be seen as cottony threadlike (mycelia) growth in the collar region
- dark brown spots then develop on the stem and the entire plant eventually turns brown
- affected plants often appear wilted and ripen prematurely due to rotting of the stems – lodging is common in affected areas
- hard, black, irregularly shaped structures (sclerotia) form in the mycelia, and these are harvested with seed or drop to the soil to reinfect in subsequent years

Sclerotinia stem and pod rot

Prevention and Control

- no fungicides are registered in Canada for use on lentils at this time
- to reduce the incidence of sclerotinia, use both a four to five-year rotation out of susceptible crops such as canola, bean, fababean, sunflower and mustard and deep burial of sclerotia

Sclerotinia stem and pod rot

Seedling Blight and Root Rot

- caused by a complex of pathogens including *Fusarium* spp., *Pythium* spp., and *Rhizoctonia solani*.
- normally affects only scattered plants and does not spread far

Symptoms

- diseased plants turn yellow and die
- the root system and base of the stem turn brown and rotten and may have white or pink mold growing on them

Prevention and Control

- no fungicides are registered for control at this time, but a four to five-year crop rotation will keep inoculum levels of these fungi low

Seedling blight and root rot

Viruses

- several viruses attack lentil, including pea seed-borne mosaic virus (PsbMV), alfalfa mosaic, bean yellow mosaic, cucumber mosaic and pea leaf roll virus
- only PsbMV is considered a slight threat in Alberta
- viruses are not considered a serious threat because of Alberta's severe winters and short growing season

Heat Canker

- not caused by a pathogen, but occurs from contact of young tender shoots with soil hot from exposure to the sun
- occurs on seedlings in late May and early June when very hot weather occurs

Symptoms

- the base of the stem is pinched at the soil surface, the leaves turn yellow and the plant usually wilts, falls over and dies
- below the soil surface, the stem and roots remain plump, white and healthy

Control

- seeding in a north-south direction and shading provided by stubble offers some protection against heat canker

Insect Pests of Lentil

In general, insects have not been a major problem in lentil production in Alberta. However, in the drier areas of the province, grasshopper and cutworm can sometimes be a problem.

Wireworm occasionally cause some problems, but only if lentil is seeded into a field that has had a forage grass crop included in the rotation. Other insects such as lygus and aphid are occasionally found in lentil but rarely at levels that justify the cost of using an insecticide.

Grasshopper

Damage

- seedlings on the edge of the field can be attacked by grasshopper nymphs as they emerge in the spring, and damage can occur at both the seedling and flowering stage – if damage occurs at seedling stage, lentil will usually regrow from buds near or below the soil surface though maturity of these plants will be delayed
- greater damage occurs if lentil is attacked in the flowering to early podding stages – in this case, yields can be reduced by as much as 90 per cent
- seed contamination with grasshopper parts can result in reduced lentil quality since grasshopper heads are similar in size to lentil and are difficult to clean out
- with early seeding, lentil will normally grow past the susceptible stage before grasshoppers emerge

Control

- Decis® (deltamethrin), Lorsban 4E® (chlorpyrifos), Pyrinex 480 EC® (chlorpyrifos and malathion 50 per cent) are registered for grasshopper control in lentil
- Decis® has greater activity in cool temperatures while malathion has greater activity in warm temperatures

Cutworm

Damage

- most cutworm damage occurs in late-May and early-June, usually at night, as larvae cut off seedlings just below the soil surface

Control

- Ambush® (permethrin), Pounce® (permethrin), Decis® (deltamethrin) and Lorsban 4E® (chlorpyrifos) are all registered for control of cutworms in lentil
- spray at night, when the cutworms are feeding

Wireworm

Damage

- most wireworm damage occurs in early spring, when larvae are close to the soil surface
- larvae eat into the lentil seeds or damage young seedlings by eating them below the soil surface
- damage is rarely a problem unless lentil is seeded into a field that has had forage grasses in the rotation

Control

- no insecticides are registered for wireworm control in lentil
- an insecticide seed treatment should be used for the first two years on cereal crops before lentil is seeded into a field that had forage grasses

Lentil Harvesting

Pre-Harvest Considerations

Under Alberta conditions, long-season varieties such as Laird seldom mature naturally. Eston lentil will mature, but unevenly, resulting in shatter losses as some pods become over-dry while others are still green.

To drydown the crop quickly and evenly, a producer can either chemically desiccate or swath. Crop staging is the same for either desiccating or swathing, but crop staging cannot be accurately determined from a distance. Fields must be thoroughly checked and sampled.

- the crop is ready for desiccation or swathing when the bottom third of the pods are yellow to brown, and seeds inside the pods rattle when shaken; upper pods will still be green but should be filled – delay beyond this stage can result in excessive shatter losses
- Reglone Pro® (diquat) is the only desiccant registered for lentil – the crop can usually be harvested 7 to 10 days after the application of Reglone Pro®
- following desiccation, straight-cut or swath immediately in front of the combine
- other products registered for pre-harvest application in lentil include Roundup Original®, Roundup Transorb® and Roundup Fastforward® – these products are not desiccants, but are intended for perennial weed control (Roundup Fastforward® is also intended to hasten crop drydown relative to untreated crop but does not function as quickly or in the same manner as a desiccant)
- do not use any product containing glyphosate on crops intended for seed

Lentil will shatter when overripe

A desiccant is recommended for even drydown

Swathing

Spring rolling lentil fields is recommended for proper swathing, since bottom pods are only a few inches off the ground. Swathing during periods of high humidity will reduce shatter losses.

- cutter bars must travel near the ground surface at an angle of between 20° and 30°
- swathers should have a pick-up reel and vine lifters for cutting lentil
  - pick-up reels should be adjusted ahead of the cutter bar and run at ground speed
  - vine lifters will provide maximum lifting action but should not be cultivating the soil
  - dirt in the swath can result in earth tag and sample downgrading

Pick-up reel and vine lifters for lentil swathing

- if the crop is lodged, cut across or at an angle to the lean to increase the effectiveness of the pick-up reel and vine lifters
- swathers with a floating or flexible cutter bar and/or adjustable gauge wheels will increase swathing speed and minimize damage to the cutter bar, especially on uneven land – a narrow swather can be more successful on uneven land
- a clean cutter bar works best – to improve cutting action, use soapy water and a scraper or a power washer to wash the cutter bar
- lentil stubble provides little for swaths to anchor to, so to avoid wind damage to swaths, ensure the crop is cut at the correct stage – swaths should be cut in the direction of the prevailing wind (a swath roller will usually cause an unacceptable amount of shatter loss)
- a swathed crop is more vulnerable to weather damage than a standing crop, and rain is a serious concern because it can cause quality loss due to sprouting and wrinkling of seed and the spread of disease to pods and seeds. Wet swaths can flatten out, making them harder to pick up (the use of swath turners or side-delivery rakes is not recommended due to excessive shatter losses)

Combining

During combining, remember that lentil is a food product. The seed's appearance is a major factor in determining quality and, therefore, price.

- for a mature standing crop, straight-cutting or swathing in front of the combine is recommended
- straight-cutting is preferred, since swathing at this time will increase shatter losses
- both operations demand specialized equipment including pick-up reels, vine lifters and flex headers – air reels have also been effective in straight-cutting operations (NOTE: techniques discussed in the swathing section also apply here)
- rotor or cylinder speed is usually a compromise between a slow speed to prevent seed damage and a faster speed to prevent cylinder plugging – the ideal is usually between 250 and 500 rpm
- set concaves to allow good threshing and separation, with minimal seed damage – since the crop threshes easily, concave settings will usually be wider
- chaffers should be set at 3/4" and cleaning sieves at 3/8" and then adjusted accordingly; tailings should be kept to a minimum, and grain and return elevator chains should be adjusted correctly to avoid splitting or cracking seed: fan speed should be increased only to the point where an acceptable clean sample is produced; excessive fan speed will blow lentil seed out the back of a combine

When to Combine

- a 16 per cent seed moisture content is considered ideal for harvesting lentil – acceptable seed moisture contents for threshing range from 16 to 20 per cent, provided adequate drying or aeration facilities are available
- while lentil is considered dry and safe to store at 14 per cent seed moisture, it should only be threshed at 14 per cent by producers who do not have drying or aeration equipment available (threshing at 14 per cent moisture will result in higher shatter losses and quality losses from seed damage)
- the moisture content of lentil seed can change quickly in warm and windy conditions, so to obtain high-quality seed, the crop should be carefully and frequently monitored before combining

Combining a lentil swath

Post-Harvest Considerations

Drying, storing and handling lentil seed are important parts of harvest, since these operations can affect the quality of this food product.

Lentil seed coats turn brown over time due to the oxidation of tannins within the seed coat itself. Oxidation occurs quickly in conditions of high temperature, high humidity and exposure to sunlight.

The objective of a drying operation is to condition lentil seed to 14 per cent moisture content at 15° C. In this condition, discoloration and degradation due to mold growth will be minimized.

Aeration Systems

- in an aeration operation, lentil provides about the same airflow resistance as wheat per unit depth, so aeration systems that perform well with cereals should perform well with lentil
- aeration fans should be able to provide 1 to 2 cfm/bu.
- drying will occur more quickly with higher air flow rates
- floors can be either partially or fully perforated, although fully perforated is preferred
- aeration systems will dry lentil at least as quickly as for the same amount of wheat
- the effectiveness of natural air drying systems is extremely weather-dependent, so these systems must be carefully monitored

Hot Air Dryers

- when using hot air dryers, lentil should not be dried more than 4 to 5 percentage points with every pass
- a cooling or steeping period of up to 8 hours should occur between every pass
- producers using hot air dryers should have buyers test samples of lentil dried at different temperatures to establish a safe drying temperature:
  - lentil seed germination will be reduced if dryer temperatures over 45° C are used – downgrading due to heat damage is also possible
  - for food grades, recent research suggests drying temperatures as high as 70° C may be possible
  - excessive seed damage will occur when seed over 24 per cent seed moisture is dried at temperatures over 38° C
- cooling lentil seed from a hot air dryer with aeration bins will help prevent damage during further handling
- belt conveyors are preferred over conventional augers

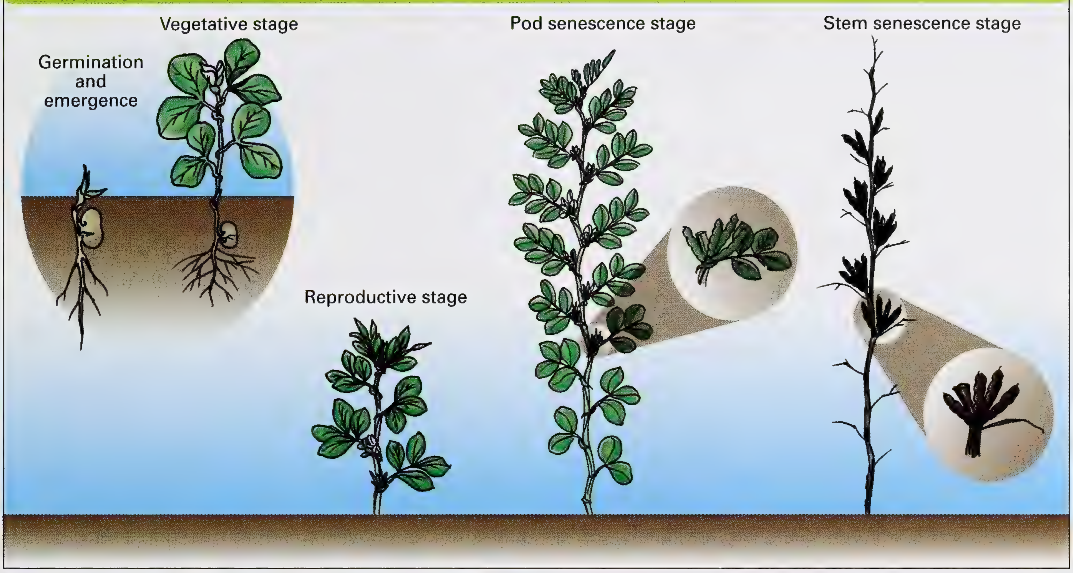
Storage

- lentil seed should be stored in tight bins and sold within two years of harvest
- seed from different years should not be mixed because of the risk of grade loss due to seed coat browning
- lentil seed that has browned may still be used for seed if germination and vigor are acceptable
- lentil seed should not be cleaned or handled when ambient temperatures drop below –20° C because of the increased risk of seed splitting and cracking

fababean

The Fababean Plant

Growth stages of fababean




Tall, upright unbranched stems

Description

Fababean *(Vicia faba)* is an annual plant with coarse, upright unbranched stems, 1 metre to 2 metres tall with one or more hollow stems coming from the base. Fababean has the ability to tiller under Alberta growing conditions.

Fababean is an erect-growing annual legume included in the same genus as vetch. It differs markedly from vetch in morphology and is not regarded as being closely related to most other species of the genus.

- classically, fababean is divided into three sub-species: *major*, *equina* and *minor*, primarily on the basis of seed size
- smaller seeded horsebean *(V. faba equina)* and tickbean *(V. faba minor)* are grown as protein crops in many areas of the world, both for human consumption and for livestock
  - these two sub-species include a seed weight ranging from 200 to 800 grams per 1000 seeds
- *V. faba major* generally has a 1000 seed weight of over 800 grams and is commonly called broadbean; it is grown primarily for human consumption
- the leaves (up to 8 cm long) are alternate, pinnate, and consist of 2 to 6 leaflets each
- plants are without tendrils, or with only rudimentary tendrils
- has a large tap root and extensive secondary root system
- new low tannin varieties are white flowered (without purple flower markings), and the seed has about 15 per cent more useable energy


Tall, erect annual

- clusters of 1 to 5 flowers are borne on short pedicels, on axillary racemes, usually between the 5 to 10 node stage (1 to 4 pods will develop from each flower cluster)
- old varieties are more indeterminate in their growth habit while some of the newer varieties are more determinate, resulting in earlier maturity

Adaptation

Fababean is a cool season crop, which prefers cool moist growing conditions. It is best adapted to the irrigated area of southern Alberta and portions of the Black soil zone with longer frost-free periods. The crop also grows well in the Peace River region as long growing days assist in shortening the days to maturity in this area.

- approximate days to maturity in Alberta are 126
- fababean is adapted to a wide range of soils, but appear to do particularly well in deep medium-textured soils that have a good water-holding capacity
- fababean performs poorly in shallow soils with a compacted layer near the surface, such as solonetzic types
- soils below pH 6.0 should be avoided since nodulation may be affected – a pH range of 6.0 to 7.2 is recommended (soils with a pH above 8.0 may require a foliar application of micronutrients, based on a plant tissue analysis)
- fababean is moderately sensitive to salinity and should not be seeded in soils with a conductivity greater than 3.5 millimhos/cm
- under conditions of high fertility and cool damp weather, the crop will be more indeterminate and mature later, resulting in feed grade
- flower set is affected by high temperatures, especially above 28° C, for an extended time – hot, dry weather will cause wilting of the plants and will reduce seed set
- fababean responds well to irrigation or ample precipitation – the plant is sensitive to moisture stress and performs poorly where moisture supply is limited
- seed fababean as early as soil conditions permit, as seedlings are very frost tolerant
- early seeding ensures maximum yield potential and allows the crop to mature before fall frosts can damage seed quality

Market Types and Uses

- recent trends have been toward a large seeded fababean – varieties with seed weights in the range of 500 to 700 grams per 1000 seeds are the preferred types for the human edible market
- for livestock feed, fababean is used as a protein supplement as the seed has a crude protein content of approximately 28 per cent
- poultry feeding trial results have been positive if supplemental methionine is added
- in swine rations, old varieties were limited in their use due to their high tannin content:
  - maximum recommended inclusion levels in swine rations are 15 per cent in starter rations, 20 per cent in grower and finisher rations and 15 per cent in breeding sow rations
  - if canola meal is blended with fababean, most rations would be well within recommendations
  - newer, low tannin varieties will be much more useful because they can be fed at much higher levels
- fababean can also be fed to calves, dairy cows, beef cattle and sheep
- tests with fababean silage have shown it to be equal to a grass-legume mix when fed to lactating dairy cows and feedlot animals:
  - silage trials done by Berkenkamp and Meeres (1986) at Lacombe showed dry matter production at 61.5 per cent of oats, but 30.7 per cent higher in protein
  - fababean and grass-legume silage, with and without grain, were equally consumed and utilized by dairy heifers and lactating cows (Ingalls et al 1979) – however, wintering beef calves and finishing steers gained more weight with fababean silage than with corn, barley or grass-legume silage
- another consideration for fababean is for human consumption; high quality fababean is always in demand from Middle East and Asian markets as well as for the canning industry in North America

Production Economics and Marketing

Introduction

Fababean may be marketed as a livestock feed or as a human edible seed. A majority of western Canadian and Alberta production is marketed as feed. Generally, markets for this crop are limited, and before growing fababean, growers are encouraged to contact various companies to see what marketing opportunities are available.

Marketing strategies for optimum returns:

- know the production costs
- know the markets you are targeting

- know the quality of fababean you've grown
- understand different types of contracts
- study and use market information sources

Cost of Production

The following Table 50 shows production cost and break-even techniques that may help producers plan a marketing strategy. In this example, if the yield for fababean was 50 bu./ac., the price required to cover all costs would be **$187.20 divided by 50 bu./ac. = $3.74/ bu.** or **60 bu./ac. = $3.12/bu.**

Table 50. Costs of production for fababean

Input		$/acre
Seed	average 198 lb./ac. @ $.20/lb.	$ 39.60
Inoculant	dry peat with sticker @ $1/bu.	3.35
Fertilizer	Nitrogen - 8 lbs. @ $.25/lb.	2.00
	Phosphorous - 30 lbs. @ $.30/lb.	9.00
	Potassium - 15 lbs. @ $.20/lb.	3.00
	Sulphur - 15 lbs. @ $.15/lb.	2.25
Herbicides		20.00
Crop Insurance		5.00
Fuel, oil and lube		8.00
Machinery repairs		8.00
Building repairs		1.00
Hired labor		3.00
Custom and machine rental		2.00
Operating loan interest		$ 8.00
Direct cash costs		**$ 114.20**
Property taxes		4.00
Farm insurance		2.00
Utilities (farm share)		2.00
Depreciation		15.00
Operator labor		15.00
Land rent or ownership cost		35.00
Total indirect cash costs		**$ 73.00**
Total Costs		**$ 187.20**

Rotational Benefits

Fababean, an annual legume, offers some rotational benefits to crop production that should be included in the economic analysis of fababean production:

- decreased need for nitrogen inputs to the following crop
- increased yields of the following crop
- increased quality of the crop grown the year after fababean (for example, protein premium on wheat)

Market Choices

- Before any seed is purchased, be sure there is a market for the crop: check both human edible and livestock feed market possibilities with buyers (for a list of fababean buyers, see www.agric.gov.ab.ca/ crops/special/directory/index.html)
- **Check all the market information sources available to determine marketability for fababean**: there are numerous weekly market information newsletters, satellite information sources (DTN, Global Link), Internet web sites (STAT Publishing) and radio commentaries
- grow for local livestock feed use

Sampling

- know what quality has been produced – take samples of the crop at harvest while it is being binned
- take the same number of cross-section samples of the grain as each lot is unloaded, to provide a representative sample for each bin
- store the composite sample for each bin in a clearly marked container, and submit a representative sub-sample to determine grade (also distribute to potential buyers)
- grading services are available from grain buying companies or by sending a sample to the Canadian Grain Commission or refer to Table 51 for fababean grades
- do a feed analysis if the grain is going to a feed market

Grading Fababean

Considerations in grading fababean:

Damage

- **Heated and/or rotted fababean**: fababean is considered heated or rotted if it is materially discolored as a result of heating or rotting; seed coats appear dark brown to black and the cotyledon tissue of dissected

Grade Table 51. Grades of fababean (Canada)*

Grade Name	Standard of Quality	Maximum Limits of				
		Damage			Foreign Material	
	Degree of Soundness	Perforated Damage	Total	Splits	Stones or Shale	Total
No. 1 Canada	Reasonably well matured, of reasonably good natural color	1.0%	4.0%	6.0%	About 0.1%	About 0.2%
No. 2 Canada	Fairly well matured, fair color	3.0%	6.0%	9.0%	About 0.2%	About 0.5%
No. 3 Canada	Excluded from higher grades on account of immaturity, poor color or damage, but cool and sweet	3.0%	10.0%	12.0%	About 0.5%	2.0%

* Canadian Grain Commission- Grades of Grain - August 1, 1997

beans appears tan or brown – samples containing over 1.0 per cent by weight of heated and/or rotted seed, or having a distinct heated or musty odor, are graded **Fababean, Sample Canada, Account Heated**

- **Mold**: fababean is considered moldy if it shows clear evidence of mildew or mold
- **Perforated damage**: fababean is considered perforated if it shows clear evidence of hull perforations caused by insects or disease – samples containing over 3.0 per cent perforated fababean by weight are graded **Fababean, Sample Canada, Account Damaged**
- **Splits**: splits include halves or smaller pieces of fababean, halves that are loosely held together by cracked seed coats and fababean with cracked cotyledons (such as from artificial drying); splits do not include any fababean otherwise damaged – samples containing more than 12.05 splits by weight are graded **Fababean, Sample Canada, Account Splits**

Foreign Material

- **Stones or shale**: hard shale, hard earth pellets, hard fertilizer pellets and other non-toxic materials of similar consistency are considered stones – samples of western fababean containing over 0.5 per cent, and up to and including 2.5 per cent, by weight of stones are graded **Fababean, Rejected (grade), Account Stones**

Contracts

Fababean can be sold through contracts. Contracting a portion of crop can reduce market risk. There are several types of contracts, with advantages and disadvantages:

Production Contract

- guarantees the delivery of some or all production to a buyer
- may or may not specify the price or total volume accepted
- some production contracts specify price for a certain volume, with over-deliveries accepted only by mutual agreement between buyer and seller and priced at the market on delivery
- a date of acceptance for delivery may be specified, and some contracts will implement a storage fee to be paid to the producer after a certain date

Deferred Delivery Contract

- also referred to as a DDC, this is an agreement to deliver a specified tonnage of a certain grade of product to the buyer by a certain date in return for a guaranteed price
- advantages to the producer of a fixed price and delivery opportunity can be considered a disadvantage later on if higher prices are offered by other buyers
- most deferred delivery contracts include escape clauses to cover the case of production failure due to adverse weather
- any contract that specifies a grade should also state how grades different from the one specified are handled – if other grades are accepted, the price and terms should be stated in the contract
- the contract should specify storage charges to be paid by the buyer to the seller, should the buyer delay delivery beyond that stated in the contract

Dealer or Producer Car Contract

- similar to other deferred delivery contracts except shipping is by producer-loaded railcar
- the difference between a dealer car and producer car is that the dealer car is allocated to a grain dealer, who in turn offers the railcar to a producer for loading, while the producer car is allocated directly to a producer for loading
- dealer car loaded product may have a lower price than a producer car since the profit for the dealer is part of the price – however, a dealer car often has a better price than sale of the same product through the elevator system
- some trade-offs exist between dealer/producers cars and elevator delivery:
  - delivery to the elevator is usually more convenient, involves less administration and can often provide mixing/blending benefits to improve grade
  - deliveries to an elevator can also result in immediate payment, while payment for railcar delivery is made after unload, which can be three or more weeks after the car is loaded

Contract Tips

Read the contract before signing it**.** This may mean getting an unsigned copy from the buyer, taking it home and taking the time to study it. Remember, contract contents can be amended by mutual agreement, and a section in disagreement can be omitted or amended to suit both parties. Answering the following can help you get the best contract arrangement:

- Are all charges accounted for?
- Is the quoted price a net price at the delivery point, or will there be additional freight charges?
- Is a grade or specification stated? Are other grades deliverable and, if so, at what premium or discount?
- How is dockage assessed? Is freight to be paid on dockage? Will dockage be paid and at what price? How are grade and dockage disputes settled?
- Is a delivery date specified? What happens when one party defaults on delivery date? Will the buyer pay storage charges after a certain date? Will the buyer pay post-delivery interest charges after a certain date?
- What protection does the seller have in case of payment default by the buyer?

Electronic Marketing

Two electronic markets are available in Alberta, and both are available through the Internet:

A.J. Bat (http://www.canadagrain.com)

- **A.J. Bat (Allan Johnston Bid-Ask-Trade)** is a site where buyers and sellers can list what they want to buy and sell
  - lot size, terms of sale and price are listed
  - there is no charge for buyers or sellers to post a bid or ask – it is between buyer and seller to work out the trucking and payment directly
  - if there is a grading problem, then the Canadian Grain Commission is consulted
  - a yearly subscription gives access to reports and listings
- **A.J.BATexport Trading Page** is where producers, processors and buyers (both locally and internationally) post product for sale or product wanted
  - all prices are converted to a common point of export depending on the crop
  - individual companies and processors then work back the price to their point of origin

Ag-Direct.Com (http://www.ag-direct.com)

- **Ag-Direct.Com** is an electronic marketplace for feed grains where customers can trade in specific regions across Western Canada
  - has approval of the Alberta, Saskatchewan and Manitoba Securities Commissions to operate as an Exchange
  - allows trading in the spot, forward and basis markets
  - the system was designed by grain traders for grain traders
  - all potential users are closely screened
  - AgraLink handles all payments and has an optional freight exchange service for trucking
  - since there is a higher level of security and services, the fee is higher than with A.J. Bat

Varieties For Alberta

Aladin

- Aladin is a tall (82 cm), late maturing (128 days), medium seed size (451 g/1000 seeds) variety
- has buff, oval shaped seed that darkens with age
- yield is 96 per cent of the check variety Outlook
- best suited to Southern Alberta under irrigation and Peace River areas of Alberta
- Aladin is a Canadian variety developed by the University of Manitoba and registered in 1981 – is a public variety with stock seed maintained by the University of Manitoba

Variety	Height cm.	Maturity days	Yield % of Outlook	Seed size g/1000	Suited to areas 1 irrigation 2 Peace 3 parkland
Aladin	82	128	96	451	1,2
CDC Blitz	75	118	103	451	1, 2, 3
Cresta	65	120	88	700	1, 2, 3
CDC Fatima	75	118	93	552	1, 2, 3
Orion	65	114	86	392	2, 3
Outlook	82	125	100	405	1, 2
Pegasus	80	120	103	419	1, 2
Scirocco	68	124	113	563	1, 2

Table 52. Fababean varieties suitable for Alberta

Note: The above figures are based on Alberta co-op test data 1996

CDC Blitz

- CDC Blitz has a tall height (82 cm), mid maturity (118 days) and medium seed size (451 g/1000 seeds)
- yield is 103 per cent of the check variety Outlook
- best suited to Southern Alberta under irrigation, the parkland and Peace River areas of Alberta
- CDC Blitz was developed by the Crop Development Centre, University of Saskatchewan, and is distributed by Proven Seeds

White flowered, low tannin variety

Cresta

- Cresta is a short (65 cm), medium maturing (120 days), very large seed size (700 g/1000 seeds) variety
- yield is 88 per cent of the check variety Outlook
- this low tannin, white flowered variety is very suitable for the livestock and human edible market
- best suited to Southern Alberta under irrigation, the parkland and Peace River areas of Alberta
- developed by Saatbau Linz in Austria and distributed in Canada by Agriprogress Inc.

CDC Fatima

- CDC Fatima is a medium (75 cm), medium maturing (118 days), medium seed size (552 g/1000 seeds) variety
- yield is 93 per cent of the check variety Outlook
- best suited to Southern Alberta under irrigation, the parkland and Peace River areas of Alberta
- developed by the Crop Development Centre, University of Saskatchewan, and is distributed by Euro-Can Seeds Ltd.-Walker Seeds(SK)

Orion

- Orion is a short (65 cm), early maturing (114 days), small seed size (392 g/1000 seeds) variety
- yield is 86 per cent of the check variety Outlook

Canadian variety

- best adapted to the cooler, moister parkland and the Peace River area of Alberta
- developed by Agriculture and Agri-Food Canada (Lacombe) and distributed by Roger Lee (AB) and Lyster Farms Ltd. (AB)

Outlook

- Outlook is a tall (82 cm), medium late maturing (125 days), medium seed size (405 g/1000 seeds) variety
- used as the check in variety comparisons
- plot trial yield averages 5410 kg/ha
- best suited to Southern Alberta under irrigation and Peace River areas of Alberta
- developed by the Crop Development Centre, University of Saskatchewan, and distributed by SeCan members

Canadian variety

Pegasus

- Pegasus is a tall (80 cm), medium maturing (120 days), medium seed size (419 g/1000 seeds) variety
- yield is 103 per cent of the check variety Outlook
- best suited to Southern Alberta under irrigation and Peace River areas of Alberta
- developed by the University of Manitoba and distributed by Roy Legumex (MB)

Scirocco

- Scirocco is a short (68 cm), medium late maturing (124 days), large seed size (563 g/1000 seeds) variety
- yield is 113 per cent of the check variety Outlook
- best suited to Southern Alberta under irrigation and Peace River areas of Alberta
- developed by Norddeutche Pflanzenzucht (NPZ) Germany and distributed by Agriprogress Inc.

Pre-Seeding Considerations

Preparation and planning are keys to successful fababean production.

- in the year before you plant fababean, grow a competitive crop, and control problem weeds with herbicides and/or tillage – use preharvest glyphosate (Roundup®, Laredo®, Wrangler®, Renegade®, Victor®) according to label directions to control perennial weeds
- do not use herbicides that leave residues harmful to a fababean crop
- plant into a clean seedbed
- follow good management practices such as seeding into a moist seedbed, using sufficient seed and adequate plant nutrients to ensure the fababean crop is as competitive and fast growing as possible
- refer to Table 53 to check wait periods between using certain herbicides and the seeding of fababean


Plant twisting caused by herbicide residues

Table 53. Fababean re-cropping restrictions for herbicides used in Alberta

Trade Name	Chemical Name	Fababean Re-cropping restrictions
Accord®	*quinclorac*	Fababean is very sensitive. Field bioassay recommended.
Amitrol-T®	*amitrole*	After post-harvest treatment of grain, pea, alfalfa or clover, do not plant to crop for 8 months.
Atrazine	*atrazine*	Fababean has some tolerance. Field bioassay recommended.
2,4-D/MCPA	*phenoxy*	2,4-D should not be applied in the spring either pre-emergence or prior to seeding. The use of high rates of 2,4-D or MCPA in the fall as spot treatments to control Canada thistle can carry over and affect fababean sown early in the following year.
Rustler® + 2,4-D	*glyphosate+dicamba + 2,4-D*	Same restrictions as with 2,4-D or MCPA.
Banvel®	*dicamba*	Do not grow fababean the year following a 1 litre/ac. rate of application.
Muster®	*ethametsulfuron-methyl*	Wait 22 months before planting fababean.
Muster Gold®	*ethametsulfuron-methyl + quizalofop-ethyl*	Wait 22 months before planting fababean.
Prestige®	*fluroxypyr + clopyralid + MCPA*	Wait 22 months before planting fababean.
Refine Extra®	*thifensulfuron methyl + tribenuron methyl*	Wait 2 months before planting fababean.
Tordon®	*picloram*	Do not plant until at least the fifth growing season after application. Field bioassay recommended.
Ally®	*metsulfuron methyl*	**Note:** Because of the lack of research work done on weed control in fababean, a field bioassay the year before planting fababean is recommended. All the chemicals listed here have recropping restrictions when growing a pulse crop. Details on re-cropping restrictions are found in the **Alberta Agriculture Agdex 142/642-1, *Weed Control in Pea - Preparing For Your Pea Crop*** or **Agdex 606-1, *Crop Protection*.** An example of crop sensitivity differences in recropping restrictions is with Ally - Black or Grey Wooded soil zone and a similar pH; for pea, the wait period is 22 months and for lentil 48 months. This is why a field bioassay is necessary when research work has not been done. *Look at the active ingredients (chemical name) to determine re-cropping restrictions.*
Amber® *Dark Brown & Brown soil zones only*	*triasulfuron*	
Assert®	*imazamethabenz*	
Curtail M®	*clopyralid + MCPA ester*	
Glean®	*chlorsulfuron*	
Lontrel®	*clopyralid*	
Poast Flaxmax®	*clopyralid, sethoxydim + MCPA*	
Prevail®	*clopyralid, tralkoxydim + MCPA*	
Unity®	*triasulfuron + bromoxynil*	
Velpar®	*hexazinone*	

Fertility Requirements


Fababean fixes large amounts of nitrogen

Introduction

- fababean is an annual legume that fits well into cereal crop rotations as it fixes a large amount of nitrogen that is released to succeeding crops
- fababean helps decrease cereal diseases – fababean crops that are kept grass and cereal-free break the root disease life cycle for diseases such as take-all
- fababean production allows growers to control competitive grassy weeds that are difficult to control in cereal crops – new grass-selective herbicides can be used on fababean
- fababean is an alternative crop to pea and lentil (where soils and growing conditions are suitable)
- a balanced soil fertility program is needed for optimum yields
- fababean will respond to added nutrients when soil tests indicate low to medium levels – soil tests aid in developing a sound fertilizer management program
- the following Western Canada Fertilizer Association chart (1992) shows that a (3360 kg/ha) 50 bushel/acre fababean crop removes the following amounts of plant nutrients from the soil:

Table 54. Plant nutrients removed by fababean - pounds/acre*

Crop	Crop Part	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	Sulphur (S)
Fababean 50 bu./ac. 3360 kg/ha.	Seed	171	61	52	7
	Straw	114	38	202	7
	Total	285	99	254	14

* to convert pounds/acre to kilograms/hectare, multiply by 1.12

Nitrogen (N)

- fababean is a legume and capable of fixing its own nitrogen needs from the air – when the seed is inoculated with the correct *rhizobium* bacteria, most of the total nitrogen in the plant will come from N fixation
- use an inoculant specially formulated for fababean
- use of additional nitrogen, other than that which comes with other fertilizer elements such as 11-51-0, is not recommended
- ensure the field is low in available N (less than 20 lb. N/ac., 0 to 24 inch depth) or the crop may not mature properly
- to allow for best N fixation, avoid fields manured in the past two years

Table 55. Phosphorus fertilizations recommendations

Phosphorus fertilizations recommendations for fababean in the different soil test areas used by the Alberta Agriculture Soil and Animal Nutrition Lab using the Miller-Axley method.

Soil test level P (lb./ac.) (0-6' depth)	P_2O_5 Recommendation (lb./ac.)					
	Brown	Dark Brown	Thin Black	Black	Grey Wooded	Irrigated
>80	0	0	0	0	0	0
60-80	20	20	20	20	20	20
50-60	20	20	25	25	25	30
40-50	20	25	30	30	30	40
30-40	25	30	35	35	35	45
20-30	30	35	40	40	40	50
10-20	35	40	45	45	45	55
0-10	40	45	50	50	50	60

Phosphorus (P_2O_5)

- phosphorus is required in relatively large amounts
- a soil test is recommended to determine optimum phosphate fertilizer rates
  - Table 55 can be used as a guide in interpreting a soil test and in deciding how much phosphate fertilizer is required
  - when using narrow openers, seed-placed phosphate (P_2O_5) should not exceed 35 lb. P_2O_5/ac. (higher rates should be banded before planting or side banded at time of planting)

Potassium (K_2O)

- potassium levels in soil are usually adequate in most fababean growing areas, so potassium is not usually required
- fababean is a high user of potassium
- if soil test levels are less than 300 lb./ac., follow the soil test recommendations

Sulphur (S)

- sulphur is required for optimum yields, but is normally not limited on most Brown, Dark Brown or Thin Black soils
- lower soil sulphur levels occur more frequently on Black and Grey wooded soil types
- soil test to a depth of 24 inches to determine if a sulphur fertilizer is required
- if soil sulphur levels are low, add replacement amounts of sulpher each year – when annual additions are made, the sulphur can be in the elemental form (very little elemental sulphur is available to plants in the year of application)
- if soil test sulphur levels are less than 20 lb./ac., follow recommendations either from the soil test report or general recommendations from Table 56

Table 56. Sulphur fertilizer recommendations

Sulphur fertilizer recommendations for fababean used by the Alberta Agriculture Soil and Animal Nutrition Lab using CaCl method.

Soil Test Level SO_4 (lb./ac.) (0-24" depth)	Sulphur recommendations (lb./ac.)					
	Brown	Dark Brown	Thin Black	Black	Grey Wooded	Irrigated
>20	0	0	0	0	0	0
20	5	5	5	10	10	10
15	10	10	10	15	15	15
10	15	15	15	20	20	20
5	20	20	20	25	25	25
0	20	20	25	25	25	30

Micronutrients

- fababean crops require a supply of all the essential micronutrients: boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn)
- if a micronutrient deficiency is suspected, a soil test should be done, and if levels are low, a test strip should be tried and evaluated before treating the whole field
- there is a lack of information on micronutrient deficiencies in fababean

Seeding Management

- prior to seeding, test all seed for germination and vigor
- fababean needs a specific inoculant with the proper strain of *rhizobium*
- inoculant may be peat based, liquid or granular – see general section on Inoculation of Pulse Crops in this publication
- treatment with a fungicide to reduce seed-borne disease and seedling rot is recommended, especially for low tannin varieties

Fababean requires *rhizobia*-specific innoculant

Time of Seeding

- seed fababean as early in the spring as possible – in all areas of the province, fababean should be seeded by May 7 to ensure enough time for proper maturity
  - fababean will germinate and emerge in soils as cool as 3° to 5° C
  - fababean seed requires a good supply of soil moisture to germinate and for the seedlings to emerge from a depth of 2 to 3 in. (5 to 7.5 cm)

Seeding Rates

- fababean population densities for optimum yield are recommended at 400,000 plants per hectare (160,000 plants per acre), 40 plants/m^2 (4 plants/ft.^{2})
- do a 1000 seed weight (1000kwt) on each seed lot prior to seeding to determine proper seeding rates – seed weights vary due to variety and growing conditions
- calibrate seed drills for each variety and seed lot prior to seeding, to ensure optimum seeding rates

For information on seeding rates, see Using 1,000 Kernel Weight for Calculating Seeding Rates and Harvest Losses, Agdex 100/22-1.


Good population density (4 plus plants per sq. ft.)

Thin plant stand and poor weed control

Seeding rate calculation (to achieve 4 viable plants per square foot)

Seeding rate (lb./ac.) = desired plant population/ft.^{2} x 1,000 kernel weight (g) ÷ expected seed survival (e.g. 0.9 = 90%) ÷ 10

Example: 1000 kwt = 450 gms, germination = 93% with 3% mortality (emergence = 0.90)
Seeding rate (lb./ac.) = 4 x 450 ÷ 0.90 ÷ 10 = 200 lb./ac. or 225 kg/ha

Seed drill calibration - based on 15 cm (6 inch) row space

Grams of seed per 100 feet of row = seeding rate (lb./ac.) ÷ 2

Example: Grams of seed per 100 feet of row = 200 ÷ 2 = 100 grams

Seed drill calibration - based on 22 cm (9 inch) row space
Grams of seed per 100 feet of row = seeding rate (lb./ac.) ÷ 2 x row space ÷ 6

Example: Grams of seed per 100 feet of row = 200 ÷ 2 x 9 ÷ 6 = 150 grams

Seeding Equipment

- growers can use the same grain drills for smaller seeded fababean as those used for other crops – for very large seeded varieties, alterations to the seeding mechanism may be required
- hoe press drills are preferred over double disc drills because when using disc drills in heavy trash or at higher speeds, some seed will be left on the soil surface
- ensure the drill has large enough seed cups and adequate metering devices to handle this large seeded crop
- adjust the drill to obtain as even a seed flow as possible
- maintain constant ground speed for even seed distribution
- air seeders are an alternative to ground driven drills; they plant seeds with precision regardless of slope or varying ground speed, but uniform depth control may be a problem – very high air flow speeds may damage fababean seeds, especially at severe bends or corners in the distribution lines and hoses
- ensure air seeders are equipped to handle and seed fababean at the proper seeding rate

Seeding Depth

- plant seeds 6 to 9 cm (2-1/2 to 3-1/2 inches) deep, depending on soil moisture
- avoid shallower seeding, especially in sandy soils
- uniform seeding into moisture will ensure uniform germination and emergence as well as a more uniform crop at maturity

Fababean – white flower – low tannin

Fababean – medium seed size

Fababean – large seed size

Post-Seeding Considerations

- following seeding, the seedbed should be well packed to conserve moisture and ensure an even germination
- throughout the summer, fields should be routinely checked for weed, insect and disease infestations so that control measures can be taken early

Table 57. Fababean field diagnostic chart

This chart will assist in field scouting. For more detail, please refer to the appropriate section in this publication.

Field/Plant Symptoms	Possible Causes
Poor or no fababean emergence or large gaps in the seed row.	• poor germination or low vigor (seed is found and may or may not be rotted) • seed decay or seed rot (seed may not be found) • no seed found: seed decay or poor seeding patterns (seeding too fast) • plumule (shoot) has been cut below soil surface: cutworm damage • plumule (shoot) below ground is brown near seed: root rot
Uniform fababean emergence, but patches are twisted, stunted or dying. Uniform fababean emergence, but patches are dying; secondary buds forming.	• possible residual herbicide damage- excess water causing root rot • high soil salinity levels • frost damage • soil residual herbicide damage • wind erosion damage
Poor root system, but not browning.	• phosphate deficiency • extremely wet soil conditions
Nodulation not present at 5-6 node stage or severely reduced.	• inoculant or inoculation problem • very acid soils • high soil nitrogen • symptom of yellow bean mosaic
Nodules present, but are green and pulpy (nodules should be pink to dark red, turning to brown as the crop starts to mature).	• high soil nitrogen • extremely dry soil conditions
Fababean plants are turning yellow.	• excess water causing root rot • no or low nitrogen fixation • herbicide residue in the soil • herbicide application damage (low water volume) • herbicide drift in pattern near edge of field • extreme drought and nitrogen fixation stops
Extremely tall growth, long internodes.	• excess fertility and moisture
Compressed plant growth, extremely short internodes.	• drought • herbicide injury from soil carry-over • herbicide injury due to low water volumes
Main plant is stalled in growth - new tillers forming.	• high soil salinity • herbicide damage due to low water volumes,cocktail mixes or sprayer tank residues • herbicide injury from soil carry-over
Twisting of main stem or leaves.	• herbicide drift • herbicide injury from tank contamination
Flowers are falling off, or pods not forming on upper flower nodes.	• flower blast due to heat stress • general drought damage
Leaves are yellow but the veins are green.	• possible fertility imbalance of magnesium or manganese deficiency (not common)
Brown spots on leaves, stems and pods.	• symptom of chocolate spot disease
Mottling of leaves, possible leaf rolling or cupping, necrotic leaf spotting that eventually extends to the shoot tip.	• symptom of yellow bean mosaic
Pod splitting and stunting.	• symptom of yellow bean mosaic
Tan colored spots on leaves, stems and pods.	• symptom of ascochyta blight

Water soaked area of the lower stem that spreads both upwards and downwards. The affected area appears bleached and turns a light brown.	• symptom of sclerotinia stem rot
Lodging.	• symptom of mycosphaerella/ascochyta and sclerotinia stem rot disease complex • excessive moisture • varietal characteristic • high soil residual nitrogen
Chewed spots or holes in pods and seeds.	• lygus bug damage
White blotches on pods.	• grasshopper damage • hail damage
White powdery coating on pods and plants.	• symptom of powdery mildew infection

Weed Control in Fababean

Good weed control is essential for optimum fababean production.

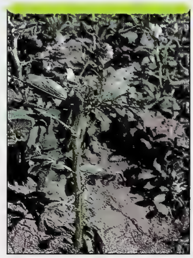
Fababean is a poor competitor with weeds especially in the seedling stage – in research plots, fababean seed yield was reduced by as much as 85 per cent when wild oat levels were high.

Good plant stand – good weed control

Cultural Weed Control

Cultural weed control can be quite variable depending on environmental conditions and stage of weed growth. Cultural weed control should include:

- appropriate tillage weed control in previous year
- careful selection of a clean seedbed
- inclusion of a shallow tillage operation in problem areas prior to seeding
- use of clean seed
- a pre-emergent harrow operation if required
- harrowing during emergence should be avoided due to excessive damage of the seedlings
- post-emergent harrowing can occur once fababean seedlings are 2 to 6 in. (5 to 15 cm) high
- tine harrows are most effective when used crosswise to the direction of seeding and at a ground speed of 6 kmph (4 mph) or less
- harrowing can increase the risk and spread of disease
- harrow on a dry, sunny day when plants are somewhat wilted
- delayed seeding should be avoided as it greatly reduces fababean yields due to late maturity



Hail damage

Chemical Weed Control

- begin weed control in the previous crop with a pre-harvest glyphosate treatment (Roundup® or Touchdown®)
- an application of glyphosate before the seed emerges will also help to control many winter annuals and very early emerging weeds
- fall application of pre-emergent, soil incorporated herbicides is recommended:
  - provides a more uniform distribution of herbicide for improved weed control and crop tolerance
  - conserves soil moisture by reducing spring tillage operations
  - allows for earlier seeding in most years

Weeds reduce fababean yield

- granular formulations are recommended for fall application into stubble; liquid formulations may be bound by the crop residues, resulting in poorer weed control
- apply post-emergence herbicides before the crop reaches 20 cm (8 in.)
- weeds tend to be more susceptible (and fababean more tolerant) at the early growth stages
- several herbicides are registered for use on fababean to control most of the common weed problems
- registered as pre-emergent herbicides: Treflan®, Bonanza 400®, Advance 10G®, Rival® (trifluralin), Edge® (ethalfluralin), Lexone® (metribuzin) and trifluralin, Sencor® (metribuzin) and trifluralin or Edge®
- registered as post-emergent herbicides: Basagran® (bentazon), Hoe-Grass 284® (diclofop-methyl) and Poast Ultra® (sethoxydim)

For detailed information on applying these herbicides and what weeds they will control, consult Agdex 606-1, Crop Protection.

Diseases of Fababean

This section outlines the key diseases in fababean, along with information on how they can be recognized and controlled.

Ascochyta Blight

- caused by *Ascochyta fabae*
- occurs everywhere fababean is grown in western Canada
- can be stubble or seed-borne
- spread occurs from spores that ooze out of the pycnidia and infect nearby plants through rain splash

Symptoms

- most important symptom is spots on the leaves, stems and pods
- on leaves, spots are circular, up to 1 cm in diameter and usually tan colored – characteristic small, black fruiting bodies (pycnidia) of the fungus form in most spots and are concentrically arranged (at a later stage, many spots merge into irregular black patches)
- on stems, spots are usually reddish-brown and more elongated
- on pods, spots are similar to those on leaves but usually more sunken, tan to black colored in the center and bordered by a dark brown margin (pycnidia are again readily observed within the spots)

Ascochyta blight

- seeds from infected pods are regularly infected and may be discolored and shriveled

Prevention and Control

- use disease-free seed and practise a four to five-year crop rotation
- avoid seeding next to previous year's fababean fields since ascospores can travel long distances by wind
- plowing or discing to bury all crop residue as soon as possible after harvest will also help prevent the fungus from being dispersed by wind and rain
- no fungicides are registered in Alberta for control of ascochyta blight

Chocolate Spot

- caused by two fungi: *Botrytis fabae* and *Botrytis cinerea*
- most prevalent under warm, wet conditions
- both fungi can be stubble or seed-borne
- spores (conidia) are produced on infected lower leaves and dead plant tissue
- conidia are spread to neighboring plants and fields by wind and rain, where they cause new infections (water is essential for their germination)

Chocolate spot

Symptoms

- occurs on leaves, stems and pods as brown markings

- lesions on leaves vary from small reddish-brown dots to well-defined areas with reddish-brown margins and tan-colored centers.
- later, lesions become entirely reddish-brown – under favorable conditions, the disease becomes aggressive and lesions may merge causing blackening and partial defoliation

Prevention and Control

- use disease-free seed and a four-year crop rotation
- plow under crop residue

Powdery Mildew

- caused by *Microsphaera penicillata* var. *ludens*
- usually appears late in the growing season and can occasionally cause serious yield losses
- overwinters on infected crop residue and as cleistothecia
- disease is favored by high humidity and warm weather
- rain and irrigation causes spores to burst instead of germinating which prevents disease development

Symptoms

- first shows up as small spots of powdery growth on the upper surface of leaves, which continue to enlarge, eventually covering the entire leaf surface with a white powdery mass
- the bottom of the leaf beneath the affected area may turn purplish, then brown
- later in the season, small oval fruiting bodies (cleistothecia) can be seen embedded in the white fungal growth – these are yellow at first, then gradually turn orange to brown and ultimately black

Prevention and Control

- do not plant fababean on the same field more than once every four years
- bury all crop residue and locate new fields away from fields where fababean was planted the previous year
- no fungicides are registered to control this disease in fababean

Root Rot and Seedling Blight

- caused by *Rhizoctonia solani* and *Fusarium* spp.
- occurs wherever fababean is grown in western Canada
- occurs on the root hairs and the main root, as well as the lower part of the stem and may even extend a short distance above the soil surface
- pathogen overwinters on crop residue and in the soil

Symptoms

- infected areas are greyish-brown to black – infection often begins on the feeder roots and progresses gradually towards the main root (in some cases, all roots are destroyed)
- symptoms on foliage are also progressive, ranging from a few yellow leaves to pronounced yellowing of the top growth and severe stunting
- if infection occurs early, it can cause seed rot and pre- and post-emergence damping-off – seedlings will sometimes show a constriction of the stem at or near the soil line
- infected seedlings usually die, resulting in poor stands

Prevention and Control

- follow a crop rotation that does not include fababean or other legumes (pea, lentil, bean, alfalfa, clovers) more than once every four to five years
- ensure good soil fertility to produce a vigorous crop stand
- no fungicides are presently registered for control of this disease in fababean

Rust

- caused by *Uromyces viciae-fabae*
- occurs only occasionally on fababean in western Canada
- overwinters on seed or infected crop residue
- can also infect lentil, pea and vetch, and these can become sources of inoculum
- produces five different kinds of spores: pycnidiospores, aeciospores, urediospores, teliospores and basidiospores
- teliospores are the most resistant and can survive up to two years under adverse conditions
- teliospores germinate in the spring and produce basidiospores that infect healthy fababean plants; urediospores (summer spores) are then produced on infected plants and are responsible for the rapid secondary spread of the disease to plants in the same field or long distances away
- both high relative humidity and late application of irrigation contribute to this disease

Symptoms

- easily recognized by rust-colored, blister-like spots (uredo sori) on leaves and stems –these sori eventually blacken due to production of another kind of spore
- a chlorotic halo may also be present around each sori,

further reducing the photosynthetic area of the plant, and premature defoliation may occur

Prevention and Control

- follow a crop rotation of four or more years between fababean crops to prevent disease build-up
- no fungicides are registered for control of this disease in fababean

Sclerotinia Stem Rot

- caused by *Sclerotinia sclerotiorum*
- considered of minor importance on fababean in western Canada
- overwinters as sclerotia in infected crop debris and soil
- small golf tee-shaped structures (apothecia) grow on the sclerotia and produce spores that infect healthy plants
- disease is favored by cool, moist conditions such as those found under a thick canopy

Symptoms

- first appears on the stem near the soil surface as a water-soaked area that spreads both upwards and downwards
- the affected area appears bleached and later turns light brown
- stems, when split open, exhibit characteristic white fungus growth – numerous, black, hard resting bodies (sclerotia) may be present in the pith
- affected plants yield poorly and often die prematurely

Prevention and Control

- a four to five-year crop rotation between fababean and other susceptible crops (canola or mustard, sunflower, dry bean, pea or lentil) is recommended
- burial of crop residue will also prevent sclerotia from germinating
- no fungicides are registered for control of sclerotinia stem rot in fababean at this time

Bean Yellow Mosaic

- caused by bean yellow mosaic virus (BYMV)
- two variants of the virus have been identified: mild (leaf mosaic with no necrosis) and severe (leaf mosaic with necrosis)
- virus is spread from overwintering hosts such as clovers and vetch to fababean by aphids

Symptoms

- affected leaves show leaf mottling and mosaic (diffuse light and dark green or yellow or green areas) – further leaf symptoms are leaf rolling or cupping, necrotic (localized dead tissue) leaf spotting and necrotic stem streaking ultimately extending up to the shoot tip
- some plants also exhibit pod splitting and stunting
- infected plants may ultimately die

Prevention and Control

- do not plant in close proximity to fields of clover and other perennial legume crops

Aster Yellows

- caused by aster yellows mycoplasma-like organism
- common on fababean throughout western Canada, but usually no more than 1 to 2 per cent of plants are affected so economic losses do not occur
- transmitted by leafhoppers from infected perennial weed hosts or carried with leafhoppers as they migrate north from the United States

Symptoms

- leaves turn yellow, first in the areas between the veins and then throughout the entire leaf, and death of leaves occurs from the margin in (defoliation of lower leaves can result)
- stunting and flower formation failure can also occur
- if plants are infected late in the season, upper pods may fail to set seed

Prevention and Control

- seeding early can help to prevent early infections
- controlling weeds around fields may help reduce local sources of infection

Insect Pests of Fababean

- no serious insect pests of fababean are known to occur in western Canada
- blister beetle, grasshopper, leafhopper and aphid can occasionally be found in fababean, but rarely at economically damaging levels
- lygus can cause quality losses – they move into fababean after other crops have matured and if numbers are high enough, can cause loss in grade (pin holes in the seed coat)
- blister beetle and grasshopper feed on fababean shoots and buds – damage is usually localized to the area being fed on
- leafhopper cause damage by transmitting aster yellows while feeding on fababean

- aphid is usually found on the stems and underside of leaves and, like leafhopper, is more of a concern because they can transmit viruses while feeding on fababean

Fababean Harvesting

Pre-Harvest Considerations

- fababean crops will mature in approximately 110 to 130 days, although this maturity time can vary greatly due to either drought or excess moisture conditions
- late seeded fields will usually have increased days to maturity
- fababean is sensitive and responsive to moisture
- time of maturity, crop height at maturity and pod ripening can vary greatly from year to year
- as fababean matures, the lower leaves darken and drop, and bottom pods turn black and dry progressively up the stem
- the crop is ready for swathing when approximately 10 to 20 per cent of the pods have turned black – this corresponds to the bottom one to three pods turning black (by this time, the uppermost pods are fully developed and the middle pods are turning a lighter green)
- a fababean crop will shatter as more pods are allowed to mature to the black stage or left standing until complete drydown – this is especially true if the crop is affected by drought
- seeds in the most mature pods will have a moisture content of over 40 per cent, while seeds found in the upper portion of the plant may exceed 60 per cent moisture content (moisture content of the whole plant will be 70 per cent or greater at this stage)

Fababean past proper harvest stage

Shattered fababean seed

- seed yield can be reduced by up to 50 per cent from harvesting too early or because of late seeded crops that don't mature before frost
- **Seed loss (lb./ac.) = Number of seeds/ft.^{2} x 1000 seed weight (g) ÷ 10**

Swathing

- swathing at the correct stage will minimize any shattering and optimize the seed yield and 1,000 seed weight
- swathed crop will have a high moisture content and will require a fairly long drying period (approximately two weeks), so lay a fairly light and even swath
- in heavy, tall stands, take only a partial cut if a wide swather is used
- a rank fababean crop might lodge – a pick-up reel is quite effective
- swathing of lodged crops in only one direction may be necessary

Desiccation

- presently, no desiccants are registered for use on fababean, although a desiccant may enhance the drying process
- several producers have used a higher rate of Reglone Pro® with a higher water volume to drydown the top portion of the stand – swathing follows about five days later (this practice is not recommended by the herbicide company)

Combining

- fababean is easily combined when the grain is at about 16 per cent moisture (dry)
- an alternative is to harvest the windrowed fababean at 18 to 20 per cent seed moisture followed by drying

and aerating – in some cases, high seed moisture may require a two-stage drying process to prevent seed coat cracking
- drying temperature should not exceed 32° C
- due to large seed size and fragile dry fababean pods, adjustments to the combine may be necessary, including the removal of concave wires to allow the seeds to pass through
- shatter losses at the pick-up can be a problem; match the pick-up speed to the ground speed
- combine cylinder speed should be in the 300 to 500 rpm range and the concaves opened wide enough to avoid seed cracking and chipping
- since fababean is relatively heavy, high air flow rates will be required for a clean sample
- combine augers and grain loaders should be run slowly to avoid seed damage
- minimize drop distances to reduce cracking because seed damages easily

Straight Combining

- fababean can be straight combined, although seed shattering can be severe if the whole plant is not dry enough to pass through the combine properly
- seed moisture content of straight cut samples is usually 22 to 26 per cent, and a two-stage drying process may be necessary
- drought stressed crops have most often been straight cut – even under these conditions, straight cutting is not recommended as a crop swathed at the correct stage can dry down evenly without shattering

Post-Harvest Considerations

- fababean is a large kernel crop, so is difficult to condition and dry
- fababean is considered dry at 16 per cent moisture content, but safe long-term storage requires moisture contents below this figure
- fababean is often highly variable in maturity and moisture content – seeds from the lower pods are more mature and drier than those from the uppermost pods
- drying and conditioning must be done carefully, as high heat air dryer temperatures damage and "case harden" the outer seed coat – dry and condition slowly to allow moisture to move from the inner portions of the seed to the surface
- combination drying (heated air drying and natural air drying) works well for conditioning fababean

Storage

To reduce cracking, always minimize drop distances when moving fababean into storage. **Fababean must be monitored closely in storage**: the crop will be graded "sample" if more than one per cent of seeds are heated or rotted, or if there is a musty, moldy or unnatural odor. Fababean will also darken over time, causing it to be downgraded, so storage over one year is not recommended. Table 58 below lists the estimated maximum storage times for fababean at various temperatures and moisture contents:

Table 58. Storage of fababean

Estimated maximum duration of storage of bean and fababean in weeks

Storage Temperature		Per Cent Moisture Content							
°C	°F	11%	12%	13%	14%	16%	18%	20.5%	23%
25	77	31	22	16	11	7	4	2	0.5
20	68	55	40	28	19	13	7	3.5	1.5
15	59	100	75	50	30	20	12	6	3
10	50	200	140	95	60	38	20	11	4.5
5	41	370	270	170	110	70	39	20	9

other pulses

Chickpea

Origin and Development

Chickpea originated in south east Turkey about 8000 years ago. Cytogenetic and morphological evidence indicate *Cicer reticulatum* L. as the wild ancestor. The cultivated chickpea *Cicer arietinum* L. is one of nine annual species of the genus *Cicer*. Within *Cicer arietinum* are two broad complexes or races, microsperma and macrosperma, that correspond best to two major seed types of chickpea: desi (small) and kabuli (large).

Kabuli chickpea is thought to have evolved from a desi type, probably by mutation. The narrow genetic base of kabulis points to this being a relatively recent event, probably within the last 2000 years.

From its origin in Turkey, chickpea was soon spread overland by traders, both westward to Europe and North Africa and eastward to India, where it arrived about 2000 BC. Kabuli types reached India in the eighteenth century. Two centuries previously, the Spanish and Portuguese had taken kabulis with them to South and Central America, but it took until the 1930's before chickpea was introduced in California.

The development of chickpea as a commercial crop in Australia began with its evaluation in the mid 1970's – it was finally established as a commercial crop in the early 1980's.

Although the wild species have been infrequently collected, are difficult to maintain and have not been studied thoroughly, some of the wild species demonstrate attributes that may be useful for genetic improvement of *Cicer arietinum*. For example, *Cicer judaicum* is said to be resistant to fusarium wilt, while some accessions of *Cicer bijugum*, *Cicer judaicum* and *Cicer reticulatum* are resistant to ascochyta blight. As well, *Cicer pinnatifidum* is resistant to botrytis grey mold.

Although crosses between the wild and cultivated species are not generally successful, *Cicer reticulatum* can be readily crossed with *Cicer arietinum* to form hybrids that exhibit only slightly reduced pollen fertility and seed set.

The Chickpea Plant

Chickpea Description

- chickpea is a short herbaceous annual, 20 to 70 cm tall (although some taller genotypes may exceed one meter under favorable conditions)

Short herbaceous annual

- chickpea has an extensive root system – the taproot often penetrates well below one metre
- the main stem gives rise to a variable number (up to seven) of primary branches near ground level
- depending on the angle of branches to the vertical main stem, growth habit ranges from near prostrate to erect – the primary branches and main stem produce a potentially large number of alternate secondary branches, with higher order branching rarely produced

Small sub-divided leaves

- foliage is similar to vetches with small subdivided leaves from 4 to 7 cm long, with 10 to 15 leaflets
- chickpea flowering is indeterminate, extending to 60 days or more – single, small purple or white flowers are produced in axillary racemes and are highly self pollinated
- the fruit is an inflated pod containing between two and four ovules

Chickpea flowers and pods

- chickpea seed (depending on type) weighs from 200 to 500 gm per 1000 seeds – kabuli (garbanzo) seeds are much larger than desi seeds


Chickpea desi type

- although seeds always possess the distinctive chickpea "beak" (radicle tip), they vary considerably in shape and color:
  - desi types have relatively small, angular seeds with rough, usually yellow to brown seed coats
  - kabuli types have larger, more rounded cream-colored seeds (their creamy white color is associated with the absence of anthocyanin pigmentation in the foliage)

Adaptation

The world's main chickpea producing regions are bounded by latitudes 20° and 40°, with the one notable exception being near equatorial Ethiopia. Although this range encompasses a diversity of soil types, temperature regimes, photo periods and rainfall distributions, two major chickpea cropping patterns can be identified:

- chickpea is adversely affected by excessive moisture and high temperatures and is therefore grown exclusively in post-rainy seasons
- chickpea is almost always grown on residual soil moisture, without irrigation

The following are other characteristics of chickpea:

- onset and duration of flowering is a function of temperature and photo period
- although some chickpea genotypes show a small response to cold-induced dormancy (vernalization), there are no true winter types


Plant drydown

- chickpea is a long day length plant, but in most environments temperature is the most important growth criteria – in areas of high temperatures and soil water depletion, physiological maturity is dramatically hastened (the ability to yield reliably under these difficult finishing conditions has contributed to chickpea's somewhat dubious reputation as a drought-tolerant species)
- chickpea grows best when daytime temperatures range between 20° and 30° C, and night temperatures range from 18° to 20° C
- desi types require approximately 110 days to mature, while kabuli types require up to 10 days longer (120 days) under optimum conditions
- chickpea is best adapted to medium textured, loamy soils, but produces well on a range of soils with good internal drainage
- chickpea prefers a soil with a neutral to slightly alkaline pH of 7.0 to 8.0 (at high pH levels, iron becomes relatively unavailable, and some genotypes show severe chlorosis)
- saline soils should be avoided when growing chickpea


Mature chickpea

World Status and Uses

Of the 57 million metric tonnes of pulses produced annually on a global basis, chickpea is the third most important, following dry bean and field pea. The average annual production of chickpea is approximately 7.2 million metric tonnes, with annual traded product at only 500,000 metric tonnes.

- desi types account for approximately 85 per cent of global chickpea production, with the bulk produced in the Indian subcontinent
- kabuli types account for about 15 per cent of global chickpea production, with major producers being Turkey, Syria, Iran, Mexico, Morocco and Ethiopia
- compared to desi types, a greater proportion of global kabuli production is traded rather than consumed domestically – Turkey and Mexico are the main exporters

- in recent years, Saskatchewan producers have shown increasing interest in chickpea production – increasing from about 10,000 acres (4,000 ha.) in 1996 to approximately 70,000 acres (28,000 ha.) in 1998 (a majority of this production is with desi types)
- chickpea is grown almost exclusively for human consumption; chickpea use is determined by seed type and ethnic culture:
  - in India, Pakistan and Bangladesh, the bulk of desi seeds are de-hulled, split and the cotyledons used as a food called dhal
  - dhal is utilized either in the preparation of a thin spiced porridge, which forms an accompaniment to most Indian meals, or is further ground to flour (besan) for the preparation of fried, sweet or savory snacks or for besan curry
  - kabuli seeds are cooked as whole seeds and are important components of many traditional West Asian and North African dishes involving rice, vegetables or meat
  - kabuli seeds can also be boiled, ground and mixed with oil to produce a dip product called hummus
  - in developed countries, whole kabuli seeds are used as a vegetable, mainly in salads, soups and stews

Production Potential for Alberta

Production of chickpea can only be considered in the south eastern part of Alberta, since chickpea needs a growing season of 110 to 120 frost-free days with high day and night-time temperatures (these climatic conditions are found in some areas of southern Alberta).

- chickpea is very sensitive to late season frosts – plant growth and seed quality will be adversely affected by as little as 2 to 3 degrees of frost during the pod filling and riping stage
- in most areas that meet growing season criteria, pre-season soil moisture reserves would have to be satisfied with irrigation
- chickpea is very susceptible to ascochyta blight, so rotational planning is critical for successful production

Ascochyta blight

From a marketing perspective, producers are encouraged to ensure a secure market is available before growing chickpea. At present, a majority of world chickpea production is of the desi type – in northern latitudes in North America, a large portion of chickpea production is dedicated to desi types since they are less affected by high quality marketing standards.

Chickpea Grading

Most Canadian chickpea production is sold to the Middle East, India, Pakistan and to South America. Currently, two types of chickpea are grown in Canada:

- kabuli – larger types used for human consumption
- desi – smaller types that are ground up into meal

An increase in the estimated production of chickpea and the need for quality assurance of the crop led to the need for a grade schedule for this commodity. Kabuli had been graded by using a "Bean" category, but this method is not suitable for desi varieties.

Consultations with the industry (the Canadian Special Crops Association and the provincial pulse organizations) led to a separate grade schedule for chickpea, implementation August 1, 1999. The grading schedule clearly establishes quality characteristics and allows clear identification for both buyers and sellers.

Table 59. Grades of Canada western chickpea*

Kabuli varieties

Grade name	Color	Damaged	Cracked seed coats including splits	Green	Foreign material
No.1 CW	Good, natural color	0.5 %	1.0 %	0.5 %	0.1 %
No.2 CW	Fair	1.0 %	2.0 %	1.0 %	0.2 %
No.3 CW	Poor	2.0 %	3.0 %	2.0 %	0.2 %
Grade, if No.3 specs not met	Chickpea, sample CW account color	Chickpea, sample CW account damaged	Chickpea, sample CW account cracked seed coats and splits	Chickpea, sample CW account green	Chickpea, sample CW account foreign material

*Canadian Grain Commission - Revised April 12, 1999

Table 59. Grades of Canada western chickpea*

Desi varieties				
Grade name	**Damaged**	**Cracked seed coats including splits**	**Green**	**Foreign material**
No.1 CW	1.0 %	1.0 %	1.0 %	0.1 %
No.2 CW	2.0 %	2.0 %	2.0 %	0.2 %
No.3 CW	3.0 %	3.0 %	3.0 %	0.2 %
Grade, if No.3 specs not met	Chickpea, sample CW account damaged	Chickpea, sample CW account cracked seed coats and splits	Chickpea, sample CW account green	Chickpea, sample CW account foreign material

Canadian Grain Commission - Revised April 12, 1999

Chickpea Grading Factors

- **damaged**: is whole or split chickpea that is sprouted, frost damaged, heated, insect damaged and chickpea that is distinctly deteriorated or discolored by weather or disease.
- **cracked seed coats**: is chickpea with visibly cracked seed coats - if the chickpea is otherwise damaged, it is included in the tolerance for damage (not cracked seed coats).
  Chickpea with all or part of the seed coat removed. Broken chickpea with less than one fourth of the chickpea broken off is considered as damage.
- **splits**: include split chickpea, broken pieces that are less than three quarters of the whole seed and halves that are loosely held together by the seed coat.
- **green**: is chickpea that when cut in half, is a distinct green throughout. Pale green or immature seeds are taken into account in the evaluation of color.
- **foreign material**: includes any material other than chickpea or split chickpea not removed in cleaning.

Color

- **good natural color**: chickpea that is sound, well matured and have a normal color.
- **fair color**: chickpea that is immature but not green, moderate amounts of adhered soil, lightly stained or otherwise moderately discolored from natural causes.
- **poor color**: chickpea that **does not** meet the definition of fair color.

Fenugreek

Origin and Development

Fenugreek is native to an area extending from Iran to northern India, but is now widely cultivated elsewhere, including China, North and East Africa, Ukraine and Greece.

The Fenugreek Plant

Fenugreek Description

- fenugreek (*Trigonella foenumgraecum*) is an annual herb of the legume family
- fenugreek leaves are alternate and consist of three ovate leaflets
- white flowers appear in early summer and develop into long slender green pods – the 60 cm (2 ft.) tall stalks almost hide the pea-shaped flowers
- mature brown pods contain up to 20 small yellow seeds

Adaptation

- production occurs in areas where temperatures range from 8° to 27° C and annual precipitation ranges from 41 to 152 cm (16 to 60 in.)
- the crop grows well within a wide range of soil pH levels (pH of 5.3 to 8.2)
- the plant thrives in full sun on rich, well drained soils
- slow and weak growth occurs under cold temperatures and wet soil conditions – cold, wet soils encourage seed decay

Seeding

- fenugreek should be treated as a hardy annual
- seed early in May in light, well-drained soil
- trials conducted at the University of Saskatchewan showed that a density of about 18 plants per metre of row, in rows 15 to 30 cm (6 to 12 in.) apart resulted in reasonable yields
- seeding rates range from 27 to 40 kg/ha. (24 to 37 lb./ac.)
- seed will germinate in two days and emerge in seven days when seeded 2 to 4 cm (0.8 to 1.6 in.) deep

Fenugreek seed

Fertilization

- fenugreek is an annual legume that requires little nitrogen fertilizer

- University of Saskatchewan studies showed 60 kg/ha (54 lb./ac.) phosphate increased yield, hastened flowering and reduced plant height compared to both an unfertilized check and a phosphate rate of 30 kg/ha (27 lb./ac.)

Harvesting

- seed is harvested in a way similar to alfalfa seed
- seed should be thoroughly cleaned to meet market standards
- studies at the University of Saskatchewan showed shattering was not a problem with fenugreek, and desiccation was not required
- the plants can be left in the field until dry (usually even after a severe frost) and then direct combined

Pest Management

Weed Control

- fenugreek is not a strong weed competitor in early growth stages
- no chemicals are registered for weed control in Canada at present, but studies at CDC South, Brooks, found the following:
  - fenugreek is tolerant to Edge® at 0.8 kg/ha. (0.7 lb./ac.)
  - Poast® can be used for grassy weed control
  - Basagran® caused unacceptable crop injury
  - Sencor® damaged young seedlings, but older plants recovered

Diseases

- two diseases, cercospora leaf spot and powdery mildew, have been observed on the crop
- leaf spot can cause serious defoliation and also affect stems and pods – if severe, it may be a serious constraint to production
- powdery mildew is not a serious disease

Insects

- aphid has been reported to be an insect pest of fenugreek
- to date, other insects have not been identified as pests

World Status and Uses

International sales are increasing and presently amount to 10,000 to 15,000 tonnes annually. India and Morocco are the major exporters, with the most important market being the Middle East.

- the principle use of fenugreek seed is for curry powder
- some seed is used in pharmaceuticals, particularly as a source of steroids
- Egypt uses fenugreek seeds for medicinal purposes, roasts the seed for coffee and consumes the sprouted seed and fresh leaves
- India also uses the leaves as a vegetable and the seed as either a spice in curry or as a source of yellow dye
- derivatives are used to flavor imitation maple syrup, vanilla compositions, rum and butterscotch
- Canada and England are testing the suitability of fenugreek as a cash crop – the primary reason it has attracted interest in Canada is for its forage value and ability to fix nitrogen

Forage Uses

- fenugreek grown at the Agriculture Canada Research Station at Kamloops, B.C., has been analyzed for its nutrient content and digestibility – when cut after 22 weeks growth, it had 14 per cent protein and 73 per cent dry matter digestibility
- studies show fenugreek has a more sustained release of nitrogen in the rumen and greater mass digestion than alfalfa
- fenugreek also contains diosgenin, a growth and reproductive hormone
- it is thought that combined effects of high digestibility and diosgenin content of the plant might result in improved growth rates and increased efficiency of feed utilization in beef cattle

Grasspea

(Chickling Vetch) *Lathyrus sativus*

Origin and Development

The genus Lathyrus contains 187 species and subspecies, but only *Lathyrus sativus* (grasspea) is widely cultivated as a food crop.

The center of origin is southwest and central Asia. The crop is widely cultivated in central, south, and east Europe, the Mediterranean and Africa. In many parts of India, it is cultivated to elevations of 1300 meters while in some parts of Ethiopia, cultivation is carried out at elevations of 2500 to 3000 meters that receive 1000 mm of rainfall.

Grasspea plants are classified on the basis of flower color, markings on pods and size and color of seeds. There is tremendous variation for morphological traits (such as leaf length) but less variation for flower characteristics. Based on geographic distribution, the blue-flowered lines are concentrated in southwest Asia

and Ethiopia, while the white and mixed color lines are found in the west, the Canary Islands and countries of the former Soviet Union.

The Grasspea Plant

Grasspea Description

- grasspea is a multi-branched sub-erect, vining or climbing herbaceous winter annual legume
- in some countries, the plant grows to a height of nine metres
- leaves are pinnately compound, usually with two leaflets, and upper leaves often have modified tendrils
- single flowers develop and can include colors in the range of reddish-purple, pink, blue or white
- pods are oblong, flat and slightly curved, and each pod has three to five seeds that are white, greyish-brown or yellowish and are usually spotted or mottled

Adaptation

- grasspea grows well on most soil types and in areas receiving 380 to 650 mm of precipitation
- optimum growth occurs when night temperatures are about 10° C and daytime temperatures are around 25° C
- a hardy crop suited to dry climates, produces good seed crops on a wide range of soils – deep, black, heavy clay soils are considered best for grasspea production
- in areas of major production, grasspea ripens in four to six months and is harvested as soon as the leaves begin to turn yellow – at harvest, pods are not left to fully ripen as fully ripe pods will shatter


Grasspea seed

World Status and Uses

In India, grasspea occupies about 4 per cent of the total pulse crop acreage and accounts for about 0.3 per cent of total pulse production – about 1.6 million hectares are seeded, producing about 0.5 million tonnes of seed.

- seeds are de-hulled and must be boiled or parched before consumption
- seeds are used in dahl preparation and bread making and are also made into paste balls or added to curry
- grasspea seeds are used in India, Ethiopia and other developing countries during times of famine as part of the diet of the poor
- seeds can also be used in making local beverages
- leaves can be used as a pot herb and consumed as a vegetable after boiling

In many areas, grasspea is primarily cultivated as a cold weather forage crop. However, people and livestock consuming older lines of grasspea as a principal diet for months can develop a paralytic disease known as Lathyrism. More modern lines have been selected for low levels of Beta-N-oxalyl-L-alpha-beta-diamino-propionic acid (ODAP). These newer lines can be consumed by humans and livestock without problems.

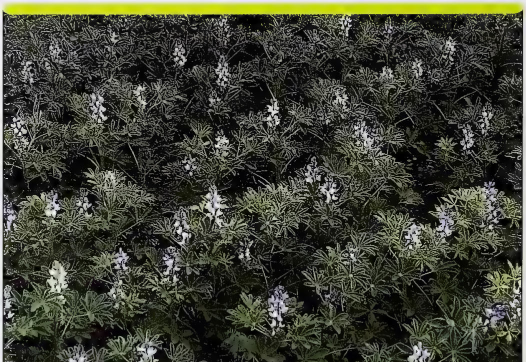
Lupin

Origin and Development

Lupin has been used in agriculture for thousands of years. Lupin belongs to the family Fabaceae. The name lupin is used broadly to include at least 12 large seeded species, but only five have been recorded as cultivated.

Prior to the 1920's, usefulness of these types was limited by the high alkaloid content of the grain. Between 1928 and 1943, German plant breeding efforts produced low alkaloid lines of *Lupinus angustifolius* L., *Lupinus albus* L. and *Lupinus luteus* L. These three species are important to varying degrees in modern agriculture.

Lupinus cosentinii Guss. and *Lupinus mutabilis* Sweet are species that have also received recent attention in selection or breeding programs. *Lupinus angustifolius* (narrow leafed lupin) and *Lupinus albus* (Mediterranean white lupin) have the most potential for commercial production.


Lupin is a herbaceous woody annual

The Lupin Plant

Lupin Description

- lupin is an erect, self supporting, herbaceous to woody annual, ranging in height from 20 to 150 cm tall when mature
- the tall, erect plant will produce basal and lateral branches depending on species and growing conditions – the number, final size and reproductive status of lateral branches are strongly influenced by genotype, duration of growing season and plant density
- lupin leaves are compound, comprising between five and eleven leaflets, depending on species, which radiate from the apex of a long petiole – leaflet shape varies from narrow and linear in *L. angustifolius* to oblong-obovate in *L. albus*
- lupin typically develops a robust tap root, from which numerous (relatively thick) lateral roots arise
- flowering usually commences soon after emergence of the terminal raceme on the main stem and continues for as long as new inflorescence form on the lateral branches –lateral inflorescence tend to have fewer flowers and shorter flowering duration than those on the main stem
- lupin pods vary in length from 35 to 150 mm, depending on the species
- pods are thick and fleshy, mainly due to the multi-layered parchment of the mesocarp of the pod wall – the outer layers of the mesocarp and the inner epidermis of the pod wall are photo-synthetic, allowing most of the carbon dioxide respired by the seeds during the daytime to be re-assimilated
- the fleshiness of fruit walls is considered responsible for delayed ripening and for increasing susceptibility to fungal attack in cool climates
- average weight, shape and surface texture of seeds vary widely between species

Adaptation

- lupin is a long day plant, and many genotypes are responsive to cold-induced dormancy (vernalization)
- floral initiation in *L. albus* and *L. angustifolius* is controlled more by vernalization requirement than by photo-period
- most lupin species are renowned for premature dropping of their flowers and fruits, especially under high temperature and low moisture stress
- cultivated lupin is a cool temperate species generally requiring a five-month growing season free from water stress and with mean monthly maximum temperatures within the 15° to 25° C range


Lupin seed

- lupin is a poor competitor with weeds during early growth, particularly when seedling growth is slowed by cool temperatures – early weed infestations can result in poor stand establishment or even crop failure
- economic yield for lupin (like any other pulse species) is influenced by plant density, number of fruits on individual plants, number of seeds contained in each fruit and average weight of seeds
- seeding rate studies for lupin have recorded good economic yield with plant densities of 90 to 100 plants per square metre
- lupin can be grown on a wide range of soils, but are markedly intolerant of waterlogged or extremely alkaline or saline soils – coarse textured, moderately acid to neutral soils (pH 5.0 to 7.0) are most suitable for most species

World Status and Uses

Sweet varieties of narrow-leafed lupin are not yet important in world agriculture or trade.

The old Soviet Union, traditionally the world's leading lupin growing area, produces 500,000 ha. of all types of sweet lupin annually. Poland is the only other significant European producer, with production of approximately 250,000 ha. Australia has surpassed European production, and annually seeds approximately 800,000 ha.

Australian production has declined in recent years because of disease problems, seasonal weather conditions, lupin prices and the price of other alternate grains (particularly cereals).

- to date, the main use for lupin grain has been in livestock rations
- acceptance of lupin as a protein source for humans has not yet occurred on any significant scale – at present, the sweet types are not completely free of alkaloids, which has prompted caution by health authorities

- lupin grain contains approximately 28 per cent crude protein and is an accepted source of protein in poultry and hog diets

Production Potential for Alberta

Lupin is considered a cool season species of the annual legume family, but has some agronomic characteristics limiting its current production potential in Alberta:

- lupin has a growing season requirement of between 120 and 150 days, which severely limits production in traditional cool season pulse production areas of the province
- southern Alberta provides the necessary long days for maturity, but crop yields suffer in this part of the province because of high temperature and frequent moisture stress (low yields are associated with high flower abortion under these conditions)
- the crop would have to compete for market share with field pea and other pulses used for livestock protein

Soybean

Origin and Development

The cultivated soybean *Glycine max* L. is a member of the subgenus *Soja*, genus *Glycine* and the family Fabaceae. Soybean is not a true pulse crop. This subgenus contains only one other species, *Glycine soja* L. While the cultivated form, *Glycine max*, has never been found in the wild, *Glycine soja* is found throughout China and the adjacent areas of the old Soviet Union, Korea, Japan and Taiwan.

Most authorities agree that domestication of soybean took place in north eastern China as early as the eleventh century BC. From China, it was introduced into Korea and Japan, probably after 200 BC, and has since spread widely throughout Asia.

Europeans became aware of soybean around the late seventeenth century, and movement of the crop into the United States took place around 1800. During the twentieth century, soybean was subject to major development in the U.S., resulting in the crop becoming dominant in world oilseed trade. Other countries, including Australia, Brazil and Argentina, have adopted soybean directly from the United States.


Soybean crop

The Soybean Plant


Maturity differences

Soybean Description

- soybean has two common growth habits:

  Indeterminate Types
  - begin to flower at lower nodes while terminal buds continue to grow vegetatively
  - flowering normally begins at the fourth or fifth node above the soil surface and proceeds at successive nodes above and below this node
  - terminal buds eventually turn reproductive and flower, with fruits first forming close to the base of the plants
  - indeterminate cultivars are grown in the northern U.S. and in soybean growing regions of Canada

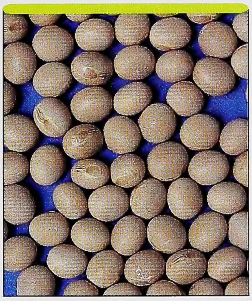
  Determinate Types
  - produce flowers at all nodes over a short period, and each terminal bud forms a distinct raceme with a dense cluster of flowers at the top of the plant
  - determinate cultivars are usually shorter and more branched than the indeterminate ones
  - virtually all soybean grown south of 36° N plus most tropical soybean are determinate


Soybean seedlings

- soybean germination is epigeal and occurs within three to four days at an air temperature of 25° to 30° C
- rate of development is controlled primarily by photoperiod and temperature – most are short day plants, but some early maturing cultivars (adapted to extreme latitudes) and a few later maturing and tropical cultivars are day length neutral during the period from planting to flowering
- flowering will begin within 25 to 50 days of planting, or even later (depending on cultivars and environmental conditions)
- soybean is almost completely self-pollinated
- pods contain from one to five ovules, but most cultivars have three ovules per pod

Adaptation

- soybean is a summer growing annual legume well adapted to moderately high temperatures
- seedling stages are frost susceptible
- air temperature above 20° C is required for optimum flowering and seed formation
- even at ripening stage, temperatures should ideally be above 18° C – highest yields are obtained when the full growth cycle is completed under high temperatures
- soybean is adapted to a wide range of soil types:
  - while neutral pH is preferred, the crop has been grown in soils ranging from pH 4.0 to 8.5
  - since high moisture availability is an important requirement for optimum yield, soil types with low moisture holding capacity can limit yield
- in more arid areas, irrigation is essential for successful soybean production – soil types with poor water infiltration (which prevents successful irrigation) can be a limiting factor


Soybean seed


Soybean – Nato type seed


Soybean – immature seed

World Status and Uses

Soybean dominates world oilseed production. The four major producers (United States, Brazil, China and Argentina) account for 90 to 95 per cent of total world production (in mid 1980's, totaled 95 million metric tonnes).

Canada and Mexico also produce large quantities of soybean – South America, Paraguay and Columbia produce in excess of 100,000 tonnes annually. Egypt and Zimbabwe are the major African producers, while Bulgaria, Romania, Yugoslavia and the former Soviet Union are major European producers. Asian countries (other than China) produce more than 100,000 tonnes annually and include India, Indonesia, Japan, North Korea, South Korea and Thailand.

The United States has more than a 90 per cent share of soybean exports. Brazil and Argentina are ranked second and third respectively.

Main importers are the European Economic Community, Japan, Spain and Eastern Europe.

- Asians have developed a large variety of foods from soybean that are classified as "fermented or non-fermented":
  - fermented products: include soy sauce, miso (fermented soybean paste), sufu (soybean cheese that originated in China), tempeh (a fermented soybean cake originating in Indonesia) and natto (a Japanese food made from fermented whole soybean)
  - non-fermented products: the principle one is tofu, a soy milk curd, used mostly in Japan and China
- soybean is an indispensable part of the diet of many Asian people as it has the most ideal amino acid balance of all vegetable proteins
- soybean oil is one of the world's major food fats and is moderate in polyunsaturated fat – it's used in the manufacture of margarine, shortening, salad oil, cooking oil, paints, varnish, printing ink, soap, synthetics and rubber substitutes
- soy flour and soy protein are increasingly being used in a wide range of food products in western diets
- soybean meal produced after crushing contains up to 45 per cent protein and is a main feed ingredient in feed rations for poultry, pork and dairy

Production Potential for Alberta

Soybean is not a true pulse crop – it is grown for premium vegetable oil and the protein meal, which is a by-product of the oil processing industry.

Early maturing soybean cultivars can be grown in southern Alberta in areas receiving 2300 corn heat units or more, but need proper irrigation. Soybean is not a high yielding crop (30 to 40 bu./ac.); it doesn't provide high dollar returns compared to other irrigated crops like dry bean.


Mature soybean

Alberta
AGRICULTURE, FOOD AND RURAL DEVELOPMENT

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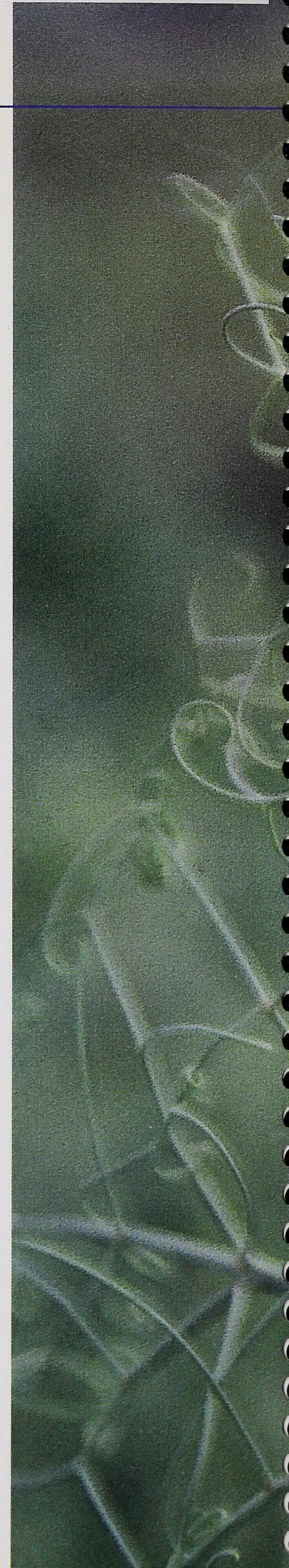

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